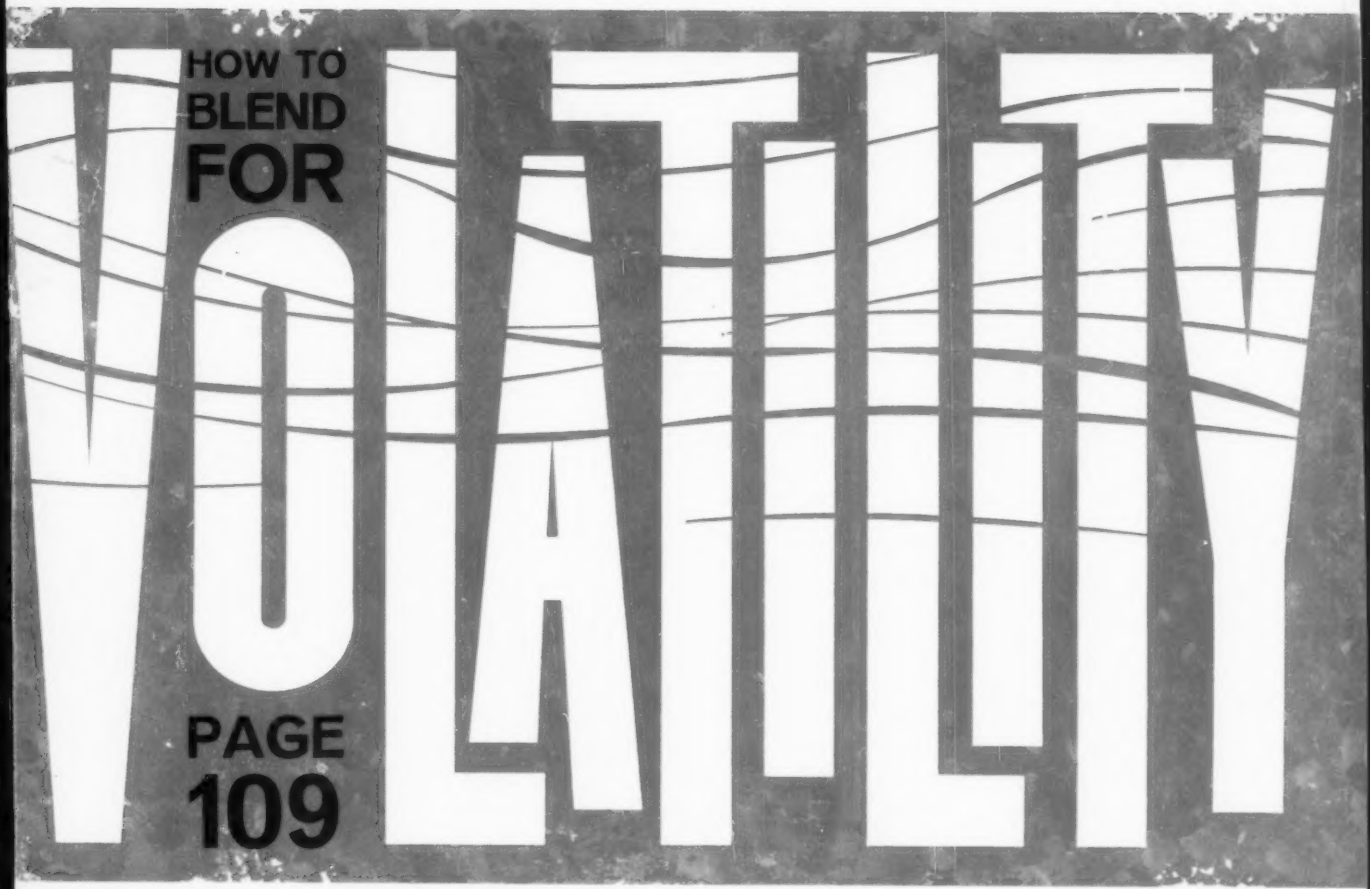
OCTOBER 1960

Petroleum REFINER

FOR THE HYDROCARBON PROCESSING INDUSTRY



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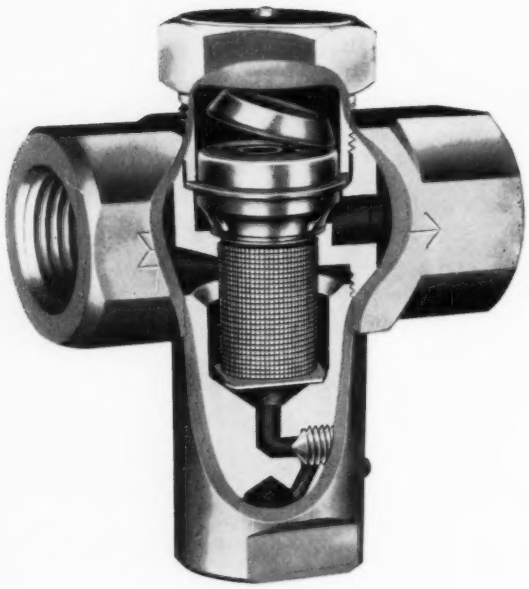
IMPULSE STEAM TRAP



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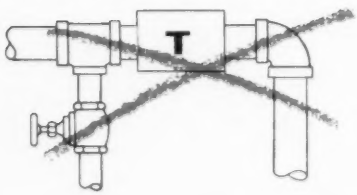

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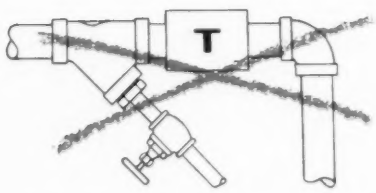

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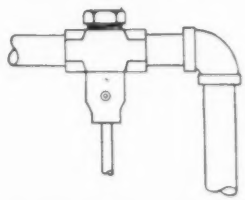

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Volume 39, No. 10 October 1960

Petroleum
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FOR THE HYDROCARBON PROCESSING INDUSTRY
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SPECIAL REPORT ON VOLATILITY

How to Blend For Volatility 109
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A Quick Look

at this issue

These handy digests permit checking ☑ the articles you want to read first.

☐ **How To Blend For Volatility . . .** This comprehensive monograph discusses engine difficulty due to fuel volatility, suggests blending goals, and tells how to predict the volatility and antiknock quality of your particular gasoline blends. You will find this report, starting on **Page 109**, a valuable addition to your reference files.

☐ **Process Viscosimeter Speeds Operation . . .** New instruments which give on-stream measurement of viscosity shorten the time required to take corrective steps in processing. Starting on **Page 141** is the principle for one such instrument and where it has been used to an advantage.

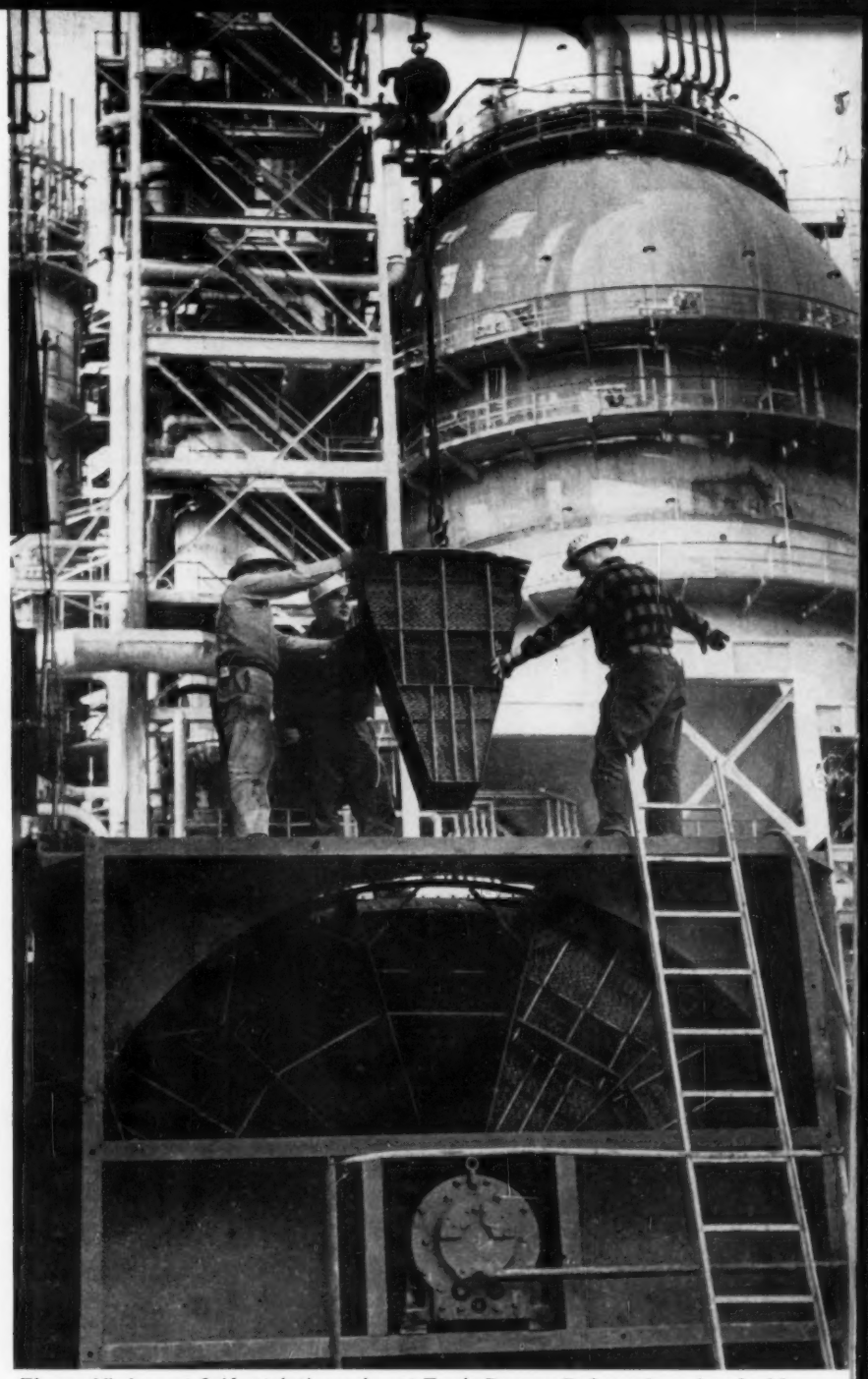
☐ **How To Specify Staged-Opening Type Valve Trays . . .** A duty-type specification is most often used when specifying valve trays because, as is true with practically all proprietary trays, the tray design procedure is not widely available. Therefore, by including certain process conditions you will get a faster quotation and more important, a tray design which is optimum for the process. For a complete list of conditions required to specify valve trays, turn to **Page 145.**

☐ **Automation Today, (Part 22) . . .** Some control systems do not have linear response. Since past discussions in this series dealt with linear systems, the authors currently will explore some of the methods for handling nonlinear ones. Turn to **Page 147.**

☐ **H-Oil Process Treats Wide Range of Oils . . .** more data on H-Oil process showing its effectiveness for raising gravity and reducing metals and sulfur are set forth in this article. See how it will fit into your process scheme—turn to **Page 151.**

Please Turn Page ➔

CUT FUEL BILLS 20% WITH A LJUNGSTROM® AIR PREHEATER



The world's largest fluid catalytic cracker at Esso's Bayway Refinery is equipped with a new Ljungstrom Air Preheater. This picture shows the half-ton cold-end elements being installed in the Ljungstrom rotor.

Your biggest refinery operating expense is the money you burn: fuel costs. You can chop fuel bills ⅓ with a Ljungstrom Air Preheater, and here's how:

Your fuel bill drops about 1% for every 45-50°F you raise the temperature of combustion air. Ljungstroms now in service raise the air temperature 1000°F or more – and the rest is simple arithmetic. With a Ljungstrom, four barrels of fuel do the work of five. On fuel savings alone, one eastern refinery came up with net savings of $67,800 in the first year they used a Ljungstrom.

SAME FUEL, MORE HEAT. Ljungstrom economy is flexible economy. If total throughput is more important to you than fuel savings, a Ljungstrom can help boost the capacity of a pipe still at least 10% a day, without any increase in fuel consumption.

THESE ARE FACTS backed up by 25 years of Ljungstrom performance in refineries all over the world. But they're not the only facts. To find out about Ljungstrom's low-cost maintenance, easy inspection, in-service cleanability, space-saving compactness, call or write The Air Preheater Corporation for a free copy of a brochure called "The Ljungstrom Air Preheater for Process Equipment."

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A Quick Look at This Issue . . .

☐ **Which to use . . . Relief Valve or Rupture Disc? . . .** The main difference is obvious—one will reseat and the other will not. The question is, where to use one or the other and when to use both? What system factors affecting disc and valve performance should be considered? What problems inherent in the devices themselves should be considered, i.e., leakage, pressure limitations and settings, capacity, etc. To see what you should do about all these things when selecting a relief valve or a rupture disc, turn to **Page 157.**

☐ **Operator's Handbook for Gasoline Plants (Part 12) . . .** This last part on plant testing and water treating shows why these auxiliary functions are important to meeting product specifications. Complete testing program for plant products is outlined in this series on **Page 163.**

☐ **Applied Hydrocarbon Thermodynamics, (Part 22) . . .** Fugacities for Components of Vapor Mixtures . . . If you've wondered how to calculate the fugacities of individual components in vapor mixtures you will have full opportunity to learn this month. Professor Edmister in the current study shows you how to handle these multicomponent calculations. See **Page 167.**

☐ **Photographs Speed Field Repair Instructions . . .** Because maintenance departments have grown during the past ten years, communications have become more of a problem. You can't rely on verbal instructions and crude sketches; and frequently management will not authorize more drafting and clerical personnel. Also, one of the big headaches in repair work is not the job itself but in finding it. Photography can solve both of these problems quickly and efficiently. To see how to speed up repair jobs in your plant, turn to **Page 173.**

☐ **How to Get Investment Efficiency . . .** How is your investment efficiency for capital projects? If yours is an average refinery, it's probably not as good as you would like for it to be. Therefore, you'll want to be sure to read this article which clearly outlines some of the causes of low investment efficiency, plus six principles you can apply to any project to make sure you are getting your money's worth. Suggest you turn to **Page 177.**

☐ **The Story Behind Intergroup Conflict . . . Applied Group Dynamics: Part 6 . . .** Ever wonder why the people in one department always seem to be bickering with those in another—why some groups never seem to work well together? This article will tell you why—and what you can do about it. You'll be referring back to this information, we predict, for many years to come. Turn now to **Page 181.**

Available—

Reprints of Petroleum Refiner's

REFINING PROCESS HANDBOOK

featured in the September 1960 issue may now be had for $1.00 per copy.

Included in the 112-page reprint:

- A total of 88 process descriptions with flow diagrams
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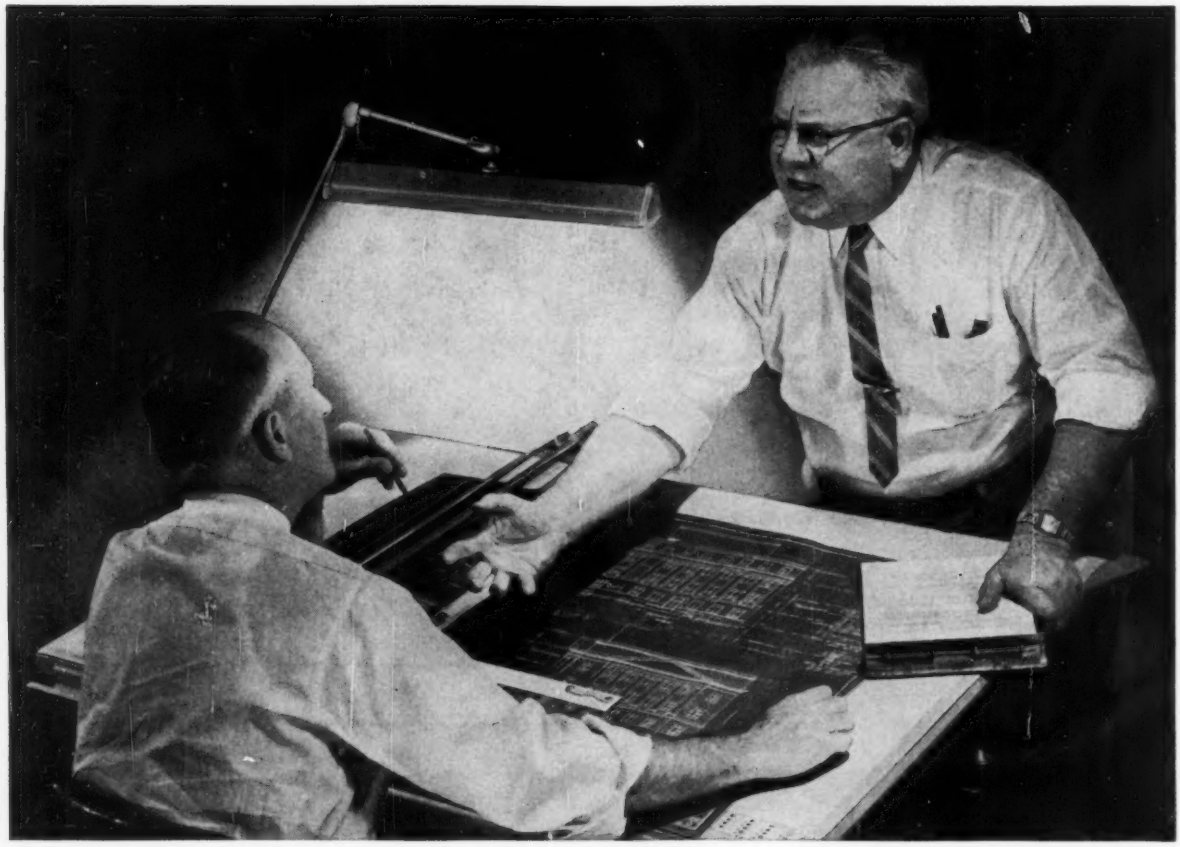
So that you may be able to keep your own copy, why not give your borrowing friend the order card from this issue? A subscription order sent in *now* will assure him of receipt of the November issue plus PR's succeeding numbers, each full of material both interesting and valuable.

Get the card mailed today!



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Another Big One

FOR PETROCHEMICALS, one November it's the Handbook and the next November it's PR's Petrochemical Developments issue. Nineteen sixty, being an "even" year, goes for Developments. And such a lineup for next month! Look:

- Polyolefin Processes Today (a 55-page review) by Marshall Sittig
- Which Isoprene Process is Best by V. J. Anhorn of Goodyear
- New Process for Pure Isoamylenes by R. A. Sanford, Sinclair Research Laboratories, Inc.
- Recent Advances in Elastomer Synthesis by Herman Mark, dean of U.S. polymer chemists
- Which Acetylene Feed Is Best? by Daniel C. Lockwood of C F Braun & Company.

There are several others just as outstanding. All are eye openers and we're satisfied our readers, when they see the treasure trove that is the November issue, will be just as excited as we are. It's a big one—worth the space in any engineer's reference file.

New Estimator Manual

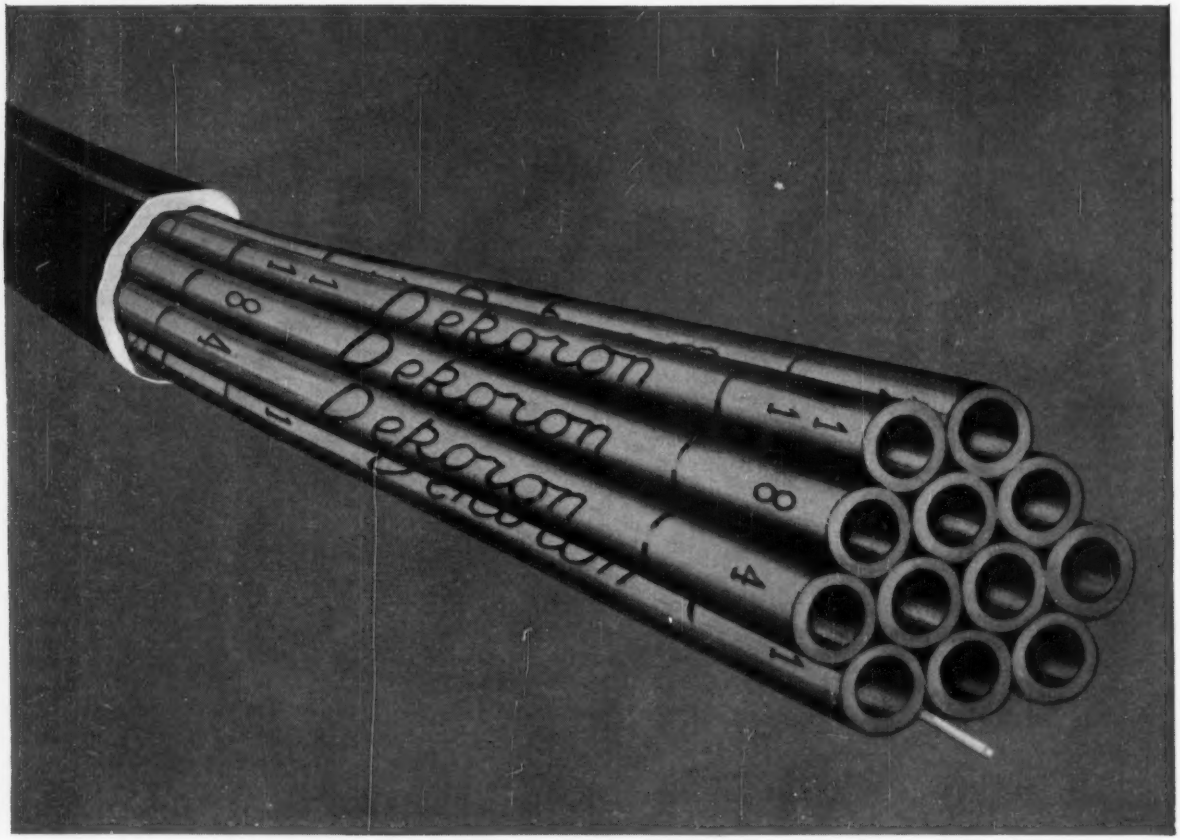
GULF PUBLISHING COMPANY'S new Labor Estimating Library continues to grow, the latest addition being "Estimator's General Construction Manhour Manual," by John S. Page. The scores of manhour tables in this manual contain thousands of easy-to-use listings—listings which are valuable guides to estimating manhours in every phase of general construction work . . . in any location. They are the result of hundreds of time-and-method studies coupled with actual labor costs of operation on numerous projects. The price $10.00 a copy. Address GPC Book Department, Box 2608, Houston.

Another manual, "Estimator's Plumbing, Heating and Air-Conditioning Manual," by the same author will be published in 1961.

Other Manuals available in group are Estimator's Piping Manhour Manual, Price $7.50 and Estimator's Electrical Manhour Manual, Price $10.00. These are by John S. Page and Jim G. Nation.

Gloved Fist

A GREAT DEAL of attention is given by our editors to the HPI Construction Boxscore, presented quarterly (see Page 215 this issue). We, first of all, know that it is never perfect but let us say this: that if editorial time and effort could make it perfect, there'd be very few flaws. Because it is under continuous study. One of our Canadian friends, bless him!, recently memoed us pointing out several items that needed correcting. "In spite of these imperfections you do a wonderful job of trying to keep up-to-date with this rapidly fluctuating world of construction. Beats me how you keep your errors at such a low level." Kind words, sir, and we do appreciate them. Even more appreciated is the listing of the incorrect items you had spotted and the data which helped us to get 'em straight. Would that more of our readers would follow suit!



New Dekoron instrument harness design uses core of Anaconda precision copper tubes

The new parallel-construction Dekoron* "Metl-Cor" instrument harness offers many interesting features. All the tubes are number-coded for faster installation. Because the tubes are parallel, there are no low spots or moisture traps – and as tubes need not be straightened, take-offs are easier to make. The tubes are protected from corrosion and physical damage by a sheath of improved polyethylene. New Dekoron "Metl-Cor," a product of Samuel Moore & Company, Mantua, Ohio, is available in lengths up to 1000 feet.

In this new product, as in other Dekoron instrument tube bundles, Samuel Moore & Co. uses Anaconda Copper Tubing because it consistently meets its rigid quality requirements and is available in unusually long lengths. Special care is taken by Anaconda to maintain dimensional accuracy and uniform soft temper throughout the length. It also makes sure that surfaces are clean, smooth, and bright, free from dirt, dust, or metal chips.

LONG LENGTHS. For such uses as in instrumentation, Anaconda can produce this precision copper tube in coils up to 2200 feet for ¼" O.D.—up to 1400 feet for ⅜" O.D.—and up to 1000 feet for ½" O.D.

QUALITY TUBE AND CREATIVE TECHNICAL SERVICES. Whatever your requirements for precision copper tubing-instrumentation or capillary tubing, or restrictor tubes – Anaconda specialists can help you find the most economical way to do the job. For such technical assistance, see your Anaconda representative, or write: Anaconda American Brass Company, Box 1031, Waterbury 20, Connecticut.

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Quick Look at Industry...

Quick Look Around the World . . .

Texaco gets tax holiday in Venezuela as country lifts 8% penalty tax on Venezuelan crude refined in certain Caribbean countries. Texaco can now process up to 200,000 bpd in its Point a Pierre, Trinidad refinery over one-year period . . . Congress okays controversial helium bill and sends it to White House . . . Texaco lands $1.3-million research contract with Air Force. Company will develop new high-energy liquid propellants.

Automation comes to rescue in solving West Germany's No. 1 chemical industry problem—acute labor shortage. Other problems in growing industry, such as exports, imports and production, become secondary to worker bottleneck . . . Italian petrochemical industry comes into own by throwing off yoke of using sulfuric acid production as barometer of chemical production.

Merging the Old and Forming the New . . .

Phillips Petroleum and Sunray Oil agree to sell all their Canadian oil and gas reserves to Pacific Petroleum for 6.6 million shares of latter's stock—worth $80 million. Deal gives Phillips working control of "Pacific Pete," with 39% of outstanding shares . . . Royal Dutch Shell and Montecatini form Netherlands company on 60-40 ownership basis to make polypropylene. The firm, N. V. Rotterdamse Polyolefinen Maatschappij, will build plant at Rotterdam . . . Humble negotiates for purchase of Monterrey Oil Co.—assets, $14 million.

A Step Past Tetramethyl . . .

Du Pont makes commercially available New additive combining tetraethyl and tetramethyl lead, and mixed methyl-ethyl lead compounds. Company has applied for patent on compound, which it says appears to work better at all concentrations than TEL or TML, and is effective in wide gasoline range.

New Capers on Jet-Fuel Scene . . .

LPG as well as methane being eyed closely as jet fuel. Advantage over JP-4: They make a better heat sink for dissipating heat at multi-mach speeds. Disadvantage: high vapor pressure, need for refrigeration and adequate tank insulation.

Study of hydrocarbon types best suited for supersonic jet fuels shows saturated monocyclics are best compromise. Example: diethylcyclohexane has high thermal stability, high heat of combustion, low luminosity, and excellent viscosity properties. Negative aspects: deficiency in heat capacity and thermal conductivity.

Competitive Vigor for Synthetic Rubber . . .

U.S. Attorney General's annual report on competition in synthetic rubber industry points to signs it is developing "competitive vigor." Government has been selling its wartime plants to private industry, but had Justice Department watch for monopoly. The big picture: Competition is big in general-purpose styrene-butadiene rubber—weaker in other areas.

First-Quarter Refining Profits Down . . .

U.S. refining companies report second-quarter 1960 net profit of $623 million, $3 million more than in corresponding 1959 period, says latest FTC-SEC report. But net profits down from first-quarter 1960 total of $684 million. Sales down $260 million from first quarter.

Isoprene Still in the News . . .

While major rubber manufacturers have just started to move into polyisoprene market, Shell Chemical puts 20,000 tons per year on market and announces 40,000-ton polyisoprene plant for Marietta, Ohio. Battle lines seem to be drawn between polybutadiene and polyisoprene synthetic natural rubber.

Quick Look at Industry (Continued)

Balloons Reduce Crude Storage Losses . . .

Sohio figures crude oil storage losses reduced 80% by using small plastic balloons on oil surface. In use for six years on more than 100 crude oil tanks, Sohio-developed method offers big savings possibilities for cone-roof tanks in entire industry. Method not recommended for storing finished gasoline or light distillates.

Scanning the New-Process Picture . . .

Process for synthetic rubber with qualities and properties of natural rubber is licensed by Goodrich-Gulf Chemicals. Federal court approved consent decree to end controversy over whether company or Government holds patent rights. Some industry authorities doubt effect of decree on other polyisoprene processes . . . Catalysed reaction touched off by electric spark is key to new polypropylene process claimed by Tokuyama Soda (Yamaguchi Prefecture, Japan). Catalyst contains special metal halide, metallic deoxidising agent, and alkyl halide. Yields not disclosed—but company says they are better than those offered by conventional processes.

Another new process converts lignite, containing its natural moisture, into intermediate product. From this, numerous chemicals recovered without destructive distillation of lignite. Patent issued to Submerged Combustion, Inc., by co-inventors R. V. Heinze of Hammond and Dr. L. H. Reyerson, University of Minnesota.

Sohio opens door little wider on new acrylonitrile process. New single-step, direct-conversion process uses fixed fluidized bed of catalyst for vapor-phase conversion of propylene, ammonia, and air to acrylonitrile. Reactor operates at less than 500° C and below 45 psi pressure. Residence time is only a few seconds.

Same Mileage Between Oil Changes . . .

Ford, Chrysler and General Motors recommend this year's crankcase-oil-change specs for new 1961 models. However, Ford suggests change at 6,000 miles for Continental. The figures: Ford, 4,000; Chrysler, 2,000; General Motors, 2,000-4,000. Specs subject to varying time intervals, seasons, other adverse conditions.

Looking Over the Demand Picture . . .

Bureau of Mines estimates amount of domestic crude oil consumed or exported in October at 6,785,000 bpd, compared with 6,980,000 bpd for September. The breakdown: total gasoline demand, 4,290,000 bpd; gasoline yield, 45.5 percent; total crude runs, 7,775,000 bpd.

Oilman's-Eye View of U.S.S.R . . .

Conoco Veep Ira H. Cram says Soviet oil men fear being spied upon by secret police. In telling of experiences on tour of U.S.S.R. with seven other oil execs, Cram said ""suitcases were continually ransacked . . . we never talked of serious matters in our rooms . . . in two oil fields and one refinery, they had more engineers than entire Conoco organization . . . look for Soviet crude exports of 500,000 bpd by 1965.''

Latest on the Compact Car . . .

Some oil experts find it hard to believe, but Detroit bigwigs look for compact cars to grab 50% of 1961 new-car market. While compact's gasoline consumption per unit is lower, total gasoline demand will be up. But look for premium-to-regular ratio to go down again. Over-all car picture: Little change in compression ratios—drop in grease demand because of few lube points—some models semi-lubefree, Cadillac completely lubefree.

Quick Look at World-Wide Construction . . .

Monsanto may build first phenol plant constructed in Texas City area. Will produce 50 million pounds a year via cumene route . . . Fish Engineering asks Argentine government for approval to construct $75-million petrochemical complex . . . Ashland Oil and Refining builds 32,000-bpd vacuum distillation unit at Catlettsburg, Ky., completion set for early 1961 . . . U.S.I. completes expansion of Houston polyethylene plant to 200 million pounds per year . . . El Paso Natural Gas Products and Compagnie Francaise de Raffinage team to build $17-million polyethylene resin plant near Le Havre, France . . . More about construction on Page 215.

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ELECTRIC PRECIPITATORS · CYCLONES · BAG COLLECTORS · FANS · COMBINATION SYSTEMS · CLASSIFIERS

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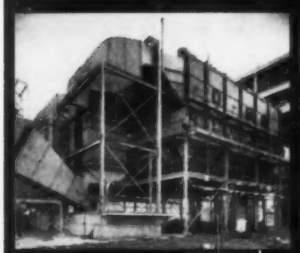
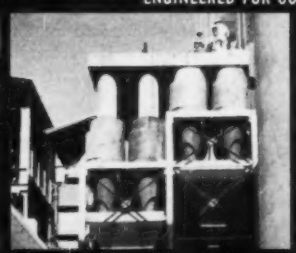
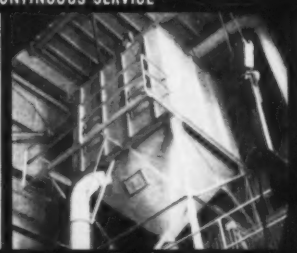


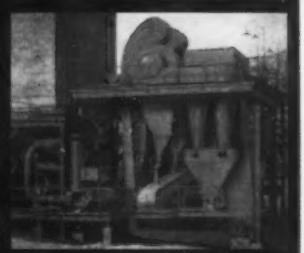
ELECTRIC PRECIPITATORS Excel in high efficiency, lowest maintenance record.



MECHANICAL COLLECTORS "Shave-off" cyclones provide superior performance to ordinary cyclones.



BAG COLLECTORS Automatic cyclic cleaning provides continuous operation at full capacity.



CLASSIFIERS Capacity to keep up with any mill . . . low power consumption, no moving parts.

For more data on advertised products, use Readers' Service Cards, last page.

From seven great Solvay plants (Baton Rouge above) stream chemicals vital to petroleum production, refining and petrochemical manufacture—caustic soda, caustic potash, aluminum chloride, chlorine, calcium chloride, and many more.

How Solvay Chemicals Serve the Petroleum Industry

Increasing demands for a diversity of chemicals satisfied by America's pioneer producer of alkalies

From the primitive Drake Well of 1859 to the complex "cat crackers" and petrochemical plants of today, oil's appetite for chemicals has grown enormously—both in the number and variety of products consumed. Closely paralleling this need, the Solvay® line of alkalies and related chemicals has been continually expanding for almost eighty years. Many of Solvay's fourteen branch offices and seven manufacturing plants are strategically near oil production and refining centers. Fast dependable supply is further assured by over two hundred local stockpoints and a nationwide network of responsible distributors. Technical service is available through skilled representatives backed by years of experience in the handling and uses of Solvay chemicals in many industries.

Major Uses of Solvay Chemicals in Petroleum

Potassium carbonate—To remove carbon dioxide and hydrogen sulfide from process gases.

Aluminum chloride—To produce detergent intermediates and other alkylates.
For isomerization.
For polymerization.
For manufacturing ethyl chloride used in tetraethyl lead.

Caustic soda—For treating applications—i.e., the removal of hydrogen sulfide and lighter mercaptans.
For doctor sweetening.
To neutralize acid treated oils.
To neutralize acidic product streams.
For electrical desalters—to control pH of their precipitated brine solution.

Caustic potash—For treating applications—i.e., the extraction of mercaptan from light petroleum fractions. Its higher reactivity and lower viscosity enables faster, more complete separation.
For desulfurizing petroleum products because of its high reactivity.
For Dualayer® Distillate Process.

Calcium chloride—A desiccant for drying LPG streams.
To recover oil from waste. Its strong electrolytic action breaks oil emulsion.

Carbon tetrachloride—For solvent extraction processes.

Chloroform—For solvent extraction processes.

Chlorine—For water treating.
For manufacturing hypochlorite used in treating gasoline.
For producing petrochemicals.

Soda ash—For water treating.
To liberate DEA from heat stable salts.

Sodium nitrite—To combat corrosion.
Used with nitrates as a heat transfer medium.

Vinyl chloride monomer—To produce plastics and surface coatings.

Chromium chemicals—To prevent water-side corrosion.
To prevent corrosion in recirculating water systems of cooling towers.

MAIL TO SOLVAY if you want further information on these products or applications. Describe below or accompany with a letter.

Name_____
Company_____
Address_____
City_____ Zone_____ State_____

68-100

Allied Chemical

SOLVAY PROCESS DIVISION
61 Broadway, New York 6, N. Y.

Send export inquiries to *Allied Chemical International*, 40 Rector St., N. Y. 6.

The Look Box...

The Giant That Keeps on Growing

An advertisement with the above caption recently appeared in several newspapers over the signature of Houston Lighting & Power Company. Its message points out so clearly the threat of socialism that faces the United States today that PETROLEUM REFINER *reproduces it here for benefit of voters who less than a month hence will be exercising their most powerful counteracting weapon—the ballot.*

WHAT IS THE BIGGEST business in the United States? American Telephone? DuPont? Metropolitan Insurance? General Motors,

It is none of these.

The largest business in this country owns some 19,000 separate commercial and industrial enterprises and an additional 2,500 defense industries.

It owns 1,205,000 square miles of land, equal to the combined area of Texas, California, Montana, New Mexico, Arizona, Nevada, Colorado, Wyoming and Oregon.

Its holdings include tens of thousands of housing units, plants that manufacture innumerable products, from clocks and chains to paint and dental equipment. It operates motion picture studios, coffee roasting plants, sawmills, printing plants—to mention only a few of its diverse enterprises.

This business operates a vast insurance system that handles one-sixth of all ordinary life insurance in force in the United States. It furnishes electric power to one-fifth of the country's population. It is heavily involved in many phases of banking and mortgage financing.

It is by far the biggest employer in the land, with nearly 5 million people on its payroll.

What is the name of this enormous business? The government of the United States of America.

THE VAST MAJORITY of Americans want no part of socialism, which is simply government ownership of ALL land, business, industry and other sources of wealth.

They are alert and ready to oppose any effort to impose socialism through violence, force or subversion.

Yet, all too few of us really understand the threat that is inherent in the continuing growth of government ownership of land and business, the chief sources of wealth and employment which are the keystones of our American system of FREEDOM.

We must realize that we can drift into socialism—without a revolution or even a vote of the people—by merely allowing the government to continue going into more and more businesses which can and should be operated by free citizens.

WHENEVER THE GOVERNMENT ENTERS A NEW FIELD OF BUSINESS IN COMPETITION WITH ITS OWN CITIZENS, OR EXTENDS THE SCOPE OF AN ALREADY ESTABLISHED GOVERNMENT ENTERPRISE, OUR NATION TAKES ANOTHER DANGEROUS STEP DOWN THE ROAD FROM WHICH THERE MAY BE NO RETURN . . . THE ROAD TO SOCIALISM!

A basic FREEDOM is the freedom to own and operate a business and make a profit. For government to engage in business is a denial of this FREEDOM to its citizens.

To CHECK the government's rush into business we must:

. . . Participate in political affairs at all levels.

. . . Inform ourselves on political issues and the qualifications and political beliefs of all candidates for public office.

. . . Cast informed votes in all elections . . . votes that will preserve our American FREEDOMS, one of which is the FREEDOM to engage in business.

Only by doing these things can we have a part in preserving our American heritage of FREEDOM.

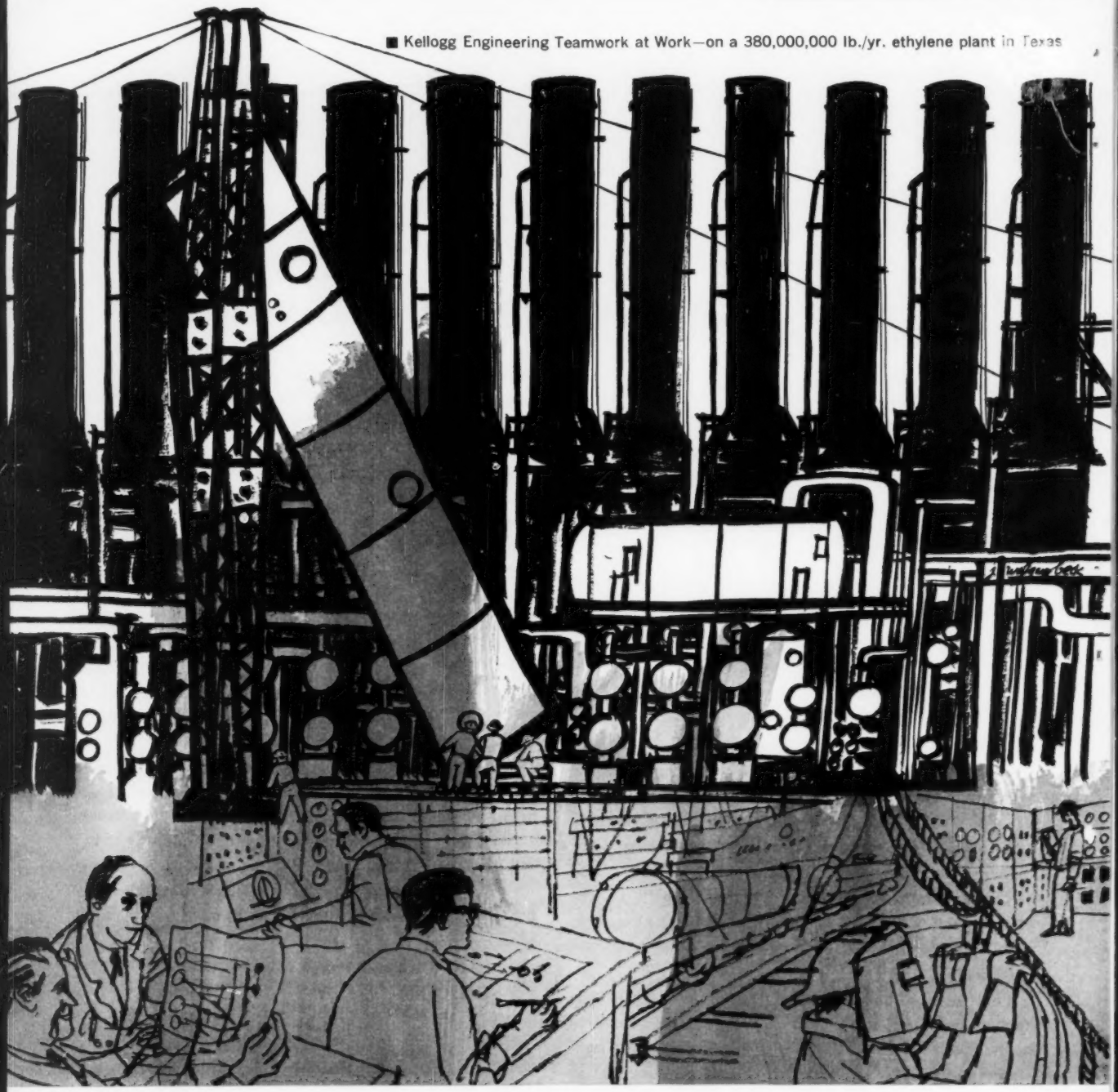
What's The Better Line?

THE UNITED STATES, as most of us know, is pursuing a line quite different from that followed by several of its Western Allies in trade and technical relations with Communistic nations. We are saying "nay" in most instances whereas many of our Allies apparently favor closer economic ties.

Imperial Chemical Industries, Ltd., other British firms, French, Swiss, Italian and German companies are establishing definite relationship with Russia, by providing the Communists with much-needed chemical facilities and products.

ICI has already supplied the Russians the know-how and patent on polyester fibers in return for

■ Kellogg Engineering Teamwork at Work—on a 380,000,000 lb./yr. ethylene plant in Texas



CHEMICAL PLANTS FROM SCRATCH

For many of the world's leading chemical and petrochemical firms, the Kellogg method of executing a capital investment in new plants and plant expansions has proved the soundest way to minimize expenditure.

This economic route to new chemical plants consists of coordinating and controlling all phases of engineering, procurement, and construction under an internationally integrated management. It is founded on close teamwork among all Kellogg operations at home and abroad . . . and with client engineering staffs.

Kellogg's method has improved process and plant engineering . . . saved money in procuring materials and equipment . . . increased labor productivity . . . expedited erection . . . achieved the earliest possible on-stream dates . . . and stayed within predetermined costs. The result is the plant which achieves the optimum balance of investment and operating costs.

Working with clients on this basis, Kellogg has been responsible for a variety of chemical plants throughout the world. In the United States, current projects include: a 380,000,000 lb./yr. ethylene plant in Texas; an 18,000,000 lb./yr. epichlorohydrin plant in New Jersey; a 300 ton/day ammonia plant in Missouri; a 200 ton/day urea plant in Delaware.

If you are planning to build new processing facilities in the U.S. or overseas, Kellogg would be glad to show you how its engineering teamwork could work to <u>your</u> company's advantage. Please address inquiries to The M. W. Kellogg Company, 711 Third Avenue, New York 17, N.Y.

THE M. W. KELLOGG COMPANY / A Subsidiary of Pullman Incorporated

Offices of other Kellogg companies are in Toronto, London, Paris, Rio de Janeiro, Caracas, Buenos Aires

M KELLOGG W

$23.5 million. The Czech National Silon Enterprise has bought $615,000 worth of rights to the processing of a polyester fiber from ICI.

Other free-world companies getting into the picture are Petrocarbon Developments, Ltd., Power-Gas Engineering and BX Plastics, Ltd. Petrocarbon Developments has sold a 40,000-tons-per-year ethylene plant to East Germany; and Power-Gas and BX Plastics have sold to Russia a 5,000-tons-per-year polystyrene plant.

ICI explains its actions as follows: 1. Russian advantages from rising standards of living cannot be improved, as a whole, from what they receive from the free world; 2. Demand for consumer goods in Russia is so great that fear of competition in the export market should be almost nil; 3. There is no nuclear warfare threat to the free world as a result of trade with Russia, because Russia could at any time tax its entire economy without the aid of imports to wage nuclear war.

In addition, ICI's chairman, S. P. Chambers, believes that the more "we trade with Communist countries and the more we exchange visits for ordinary commercial or industrial purposes as distinct from mere sight-seeing, the better we shall understand each other and the more chance there is of reducing international tension."

Also, some British firms see trade with the Communist bloc as a possible means of making up the loss of business should the European Free Trade Association fail to conclude a successful agreement with the European Common Market. Nevertheless, most British, as well as other Western European firms look upon the Russian trade market as being only secondary.

The United States has three points of argument against the trade with Russia and its satellites: 1. It is an aid to an unfriendly competitor; 2. It is a means of assisting Communist countries in waging economic warfare; 3. Selling processes to Russia releases Soviet technical resources for military applications.

Thus there are the two widely varying schools of thought. Which is the right one only time will tell, but whatever the outcome let us hope that the free world's position will be bettered in the long run.

United States Steel believes so completely in the growth of our economy that in the past 18 months we have spent $588 million for modernization and replacements—and have authorized $675 million more for the near future . . . U. S. Steel has been making calculated risks in the field of capital expansion for almost 60 years . . . It is betting on the strength of America—the military, the moral, the economic strength of the nation—and its people. And we are betting that we had calculated the risks correctly, and that America will take off, as Lindbergh took off from Roosevelt Field, and clear the wires at the end of the runway.

—Bennett S. Chapple, Jr., Vice President
United States Steel Corp.

More Competition Seen in Rubber

AS NATURAL RUBBER growers were meeting on one side of the globe to plan the future of tree rubber—increased production, lower price, and better quality—construction was well underway in the United States on several new synthetic rubber plants. These will produce new stero specific rubbers, commonly known as synthetic natural rubbers.

Current U.S. consumption of natural rubber is about 540,000 long tons per year. Synthetic (all types) runs about 1,115,000 long tons. With the present building program for synthetic natural scheduled to put 200,000 tons per year on the market by the end of 1961, U.S. imports of tree rubber could be cut in half. And the U.S. natural-synthetic ratio could be cut to about 20:80.

Since the U.S. consumes about half of all the rubber produced in the world—64 percent of the synthetic and 26 percent of the natural—this move to a higher synthetic consumption probably will affect world markets for natural. Current supply and demand for natural is about equal with price fluctuating between 40 and 45 cents per pound. The net effect of U.S. increased use of synthetic would be to add 200,000 tons to the available natural supply. This 10 percent excess in natural supply could be a real burden for the growers with a resulting price decline.

What's behind this current building trend for the synthetic natural plants?

First, there's the U.S. tradition of independence—freedom from the restrictions of imports and uncontrollable price changes.

Then there is the challenge of improved technology in synthetic rubber manufacture. Just being able to make a synthetic natural rubber which can complete in every way including price is quite an accomplishment.

Third is product quality. Natural rubber could never claim consistent and standard quality, although through current research a remedy for this disadvantage is being sought. Synthetic material, on the other hand, can be controlled regardless of the whims of nature.

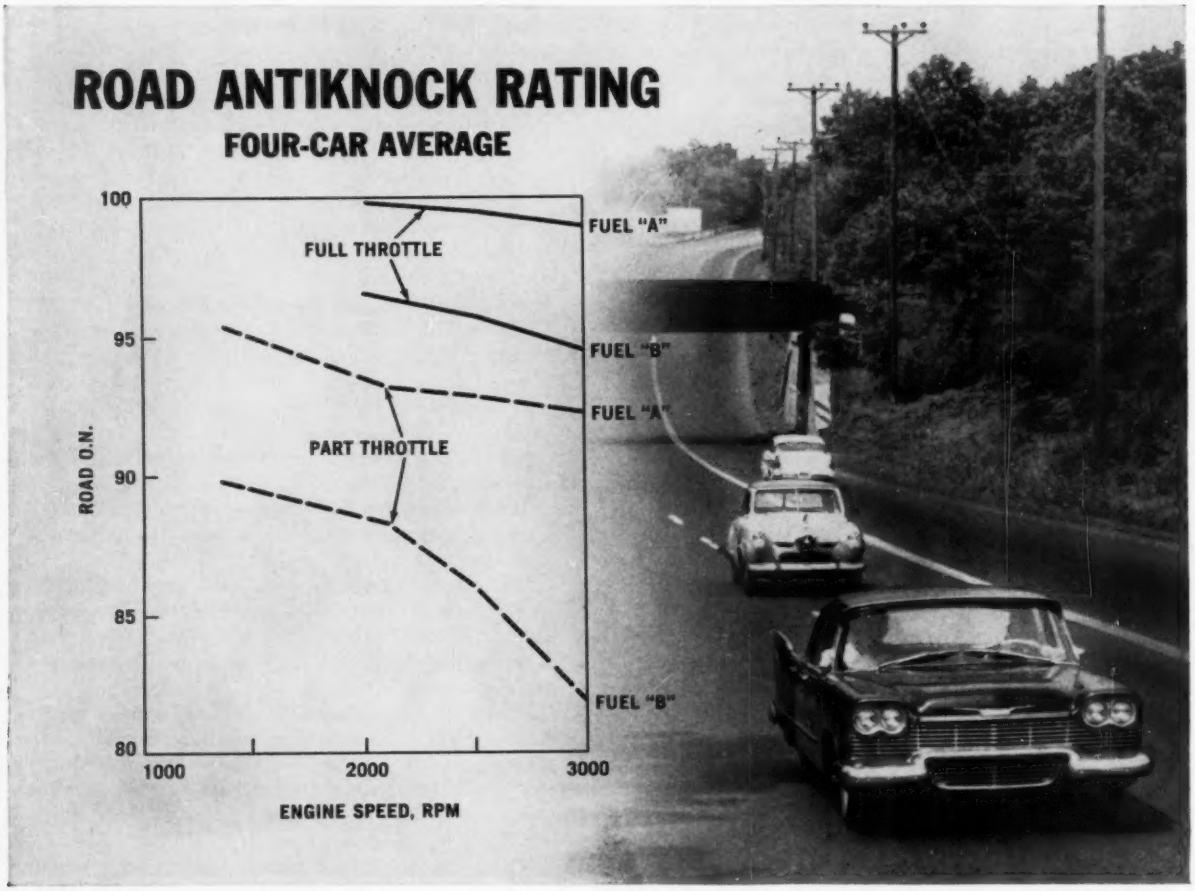
Price stability is the fourth factor. Price charts for tree rubber show a rising trend with many intermediate ups and downs. Historically, synthetic rubber has maintained a constant price. Even with quality and processing improvements, synthetic prices have remained the same.

Finally is the ability of synthetic to fill an increased demand on short notice. The two years usually required to build a process beats by far the seven years a rubber tree needs to begin production.

All this means continued brisk competition between natural and synthetic. Rubber growers realizing their plight are carrying on intensified research on product, trees and improved processing. The large investment in synthetic plants requires capacity production. Unit costs can and will be lowered. The end result should be better rubber at lower prices.

There's a Road Bonus

your best buy for



Your customers—passenger car drivers—are the final judges of the antiknock quality of gasoline, by its performance in their cars on the road.

Designing a fuel to a given Research octane number specification by using a higher antiknock compound concentration will result in a road octane bonus which can pay off in terms of customer satisfaction. This is particularly significant when guarding against high-speed or part-throttle knocking problems.

That's why the road bonus that you get from antiknocks—the extra octane, over and above Research and Motor ratings—is so important.

TEL Road Bonus Demonstrated

Road bonus from antiknocks has been demonstrated by tests performed on two fuels of the same hydrocarbon-type composition, and similar distillation ranges and sulphur content. Specific aromatics, olefins and saturates were selected carefully for each blend so that both had the same nominal laboratory octane ratings.

The only difference between the two fuels was

For more data on advertised products, use Readers' Service Cards, last page.

from Antiknocks...

road performance

in TEL content: Fuel A contained 3.0 ml TEL/gal and Fuel B contained no TEL.

Demonstration Fuels

	A	B
Res. O.N.	98	98
Motor O.N.	88	88
% Aromatics	40	40
% Olefins	5	5
% Saturates	55	55
TEL ml/gal	3.0	0.0

Because the beneficial effects of TEL vary with car make and speed, results were based on a four-car average of current models. Test results—charted on the facing page to the left—rated Fuel A (with TEL) from three to five Road octane numbers higher than Fuel B (without TEL). Although not shown in the chart, the increase in road performance is naturally greatest with the addition of the first ml/gal, but—at the other end of the scale—the road bonus continues to go up with the use of a fourth ml/gal.

What This Means to Refiners

As you can see from the chart, the effect of TEL is greatest at high speeds, generally the critical point with modern vehicles and sensitive fuels. Part-throttle operation with certain vehicles also is critical and here the TEL bonus again is significant.

Because of this road bonus, the use of higher concentrations of antiknocks is generally the most economical means of purchasing road performance on a ¢/Road octane barrel basis.

What About the Future?

There are a number of antiknocks and "extenders" now in the development stage. Most of them promise extra quality on the road. Additive octanes from combinations of antiknocks may soon be allocated to various gasoline grades to optimize the road bonus effect at lowest cost.

For additional data on Road octane bonus from TEL, ask your Ethyl Representative for a copy of the SAE paper, "Are Octane Numbers and Hydrocarbon Type Enough?" He will be glad to see that you get one.

REMINDERS TO REFINERS

Antiknocks are your best octane improvement buy, whether costs are figured on Research, Motor or Road ratings.

Antiknocks give you a Road octane bonus you can't get any other way.

Gasoline sensitivity can be decreased with antiknocks.

Refining flexibility can be increased with antiknocks.

Antiknocks also can reduce or delay capital investment in octane improvement equipment.

ETHYL® ANTIKNOCK COMPOUND —ETHYL— CORPORATION

ETHYL CORPORATION, NEW YORK 17, N. Y. • TULSA • CHICAGO • LOS ANGELES

ETHYL CORPORATION OF CANADA LIMITED, TORONTO • **ETHYL USA (EXPORT)** NEW YORK 17, N.Y.

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CRY-
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ICS

YOUR KEY TO MORE PROFIT

In the petroleum and petrochemical industries, new applications of cryogenics (low temperature separation) are opening the way to more profits.

Interested in low cost production of oxygen, nitrogen, argon, methane? purification or liquefaction of gases? Think *first* of Messer!

Write for *free illustrated brochure.*

Messer

AMERICAN MESSER CORPORATION
Chrysler Building, 405 Lexington Ave.
New York 17, N.Y.

INDUSTRY IQ QUIZ

Test your industrial IQ with this quiz on the current issue of PETROLEUM REFINER

1. In field repair work, the usual problem is not doing the work but finding it. True or False?

2. Moisture in commercial propane, as determined in natural gasoline plant testing, is reported as:

(a) Pounds of water per cubic foot

(b) Grains of water per cubic foot

(c) Dewpoint, degrees Fahrenheit

3. Car problems due to fuel volatility are seasonal in nature. True or False?

4. Since tray design procedures have been well publicized, an equipment type specification is most often used when specifying valve trays. True or False?

5. The specific gravity of the system fluid has a great effect on the *operation* of a relief valve or rupture disc; however, the relieving capacities of these devices are not affected by fluid specific gravity. True or False?

6. To be absolutely safe in the event of an emergency, refiners should have on hand at least 100 percent spare equipment. True or False?

7. The fugacity of the vapor of multicomponent mixtures is more easily (and more accurately) determined than the fugacity of the liquid. True or False?

8. Hydrogen treatment of heavy residuum oils lowers the API gravity. True or False?

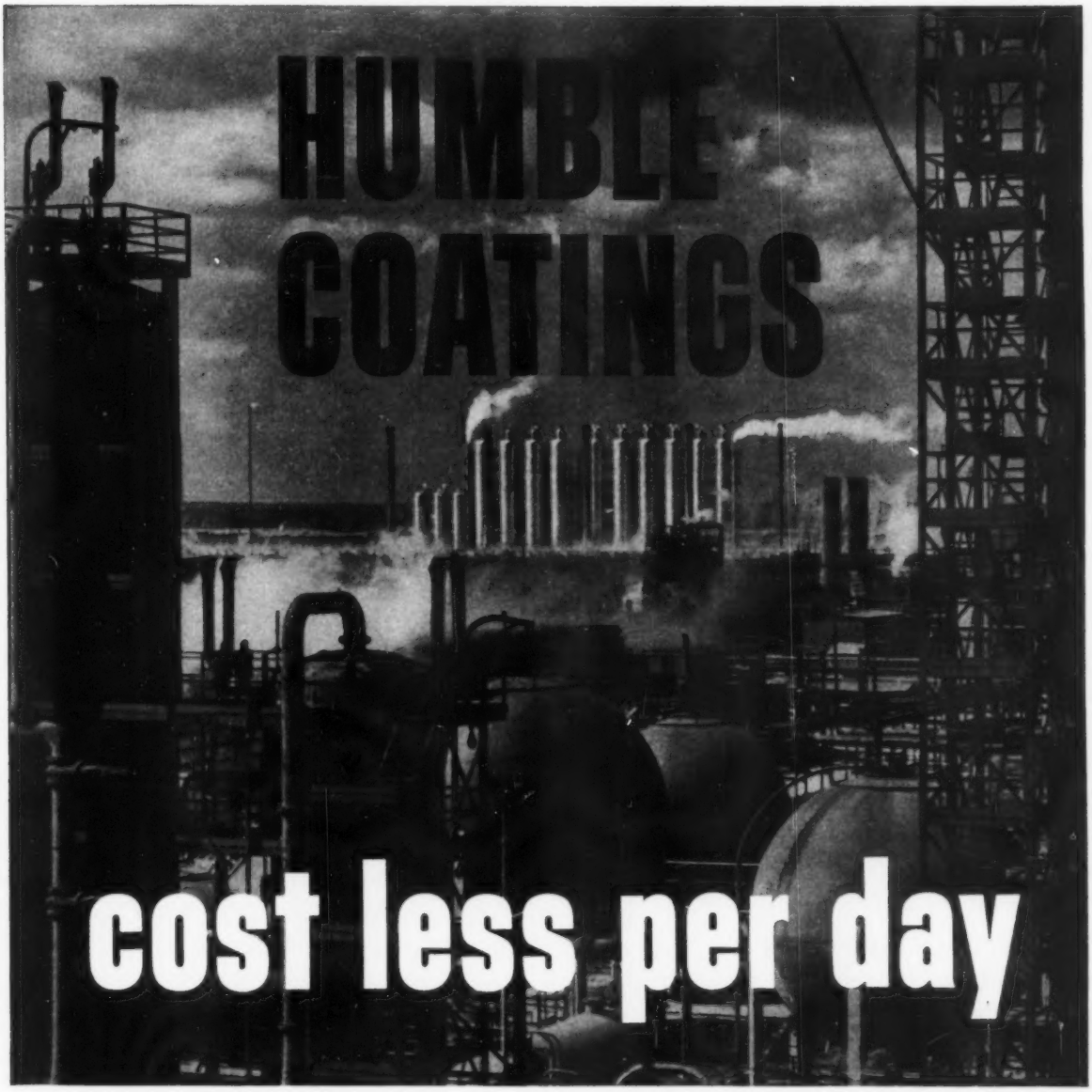
9. Nonlinear control systems can be represented by differential equations that are either constant or functions of time only. True or False?

10. Viscosity measurements by on-stream analyzers were found to be too inaccurate for use in process control. True or False?

11. Which of these car problems are due to the effect of hot weather:

(a) Vapor Lock
(b) Hot Starting
(c) Hot Idle
(d) Warm Up

Answers on Page 227



Humble paints and protective coatings last longer – extend the interval between your repaints by six months to a year. Fewer paint jobs mean savings on paint and labor. Cost per day is that much less.

But this is your big saving: Humble coatings give you better protection – they pay off in longer life for expensive equipment.

Developed to give maximum protection under the severe corrosive conditions in refineries and chemical plants, these continuously improved coatings have been profitably used by industry for over 25 years.

For more information on Humble's complete line of paints and protective coatings call your Humble salesman, or contact Humble Oil & Refining Company, Houston, Texas.

HUMBLE

HUMBLE OIL & REFINING CO.

For more data on advertised products, use Readers' Service Cards, last page.

WHERE DO YOU STAND ON COMPUTER CONTROL— LEADING OR LAGGING?

Far-sighted leaders in industry are realizing the benefits made possible by applying computer control systems to their processes.

Working with these leaders, General Electric has already pioneered the application of twenty on-line GE-312 computer systems now being implemented in these basic areas —STEEL, ELECTRIC UTILITIES, CHEMICAL, CEMENT, and PRODUCTION CONTROL for various manufacturing applications.

The GE-312 Computer Control System embodies adaptability and flexibility to meet many types of applications in varying size plants. For example, compare its expansible memory—capacity up to 52,000 words. Compare its flexible input/output—capable of scanning up to 1500 instrument inputs. These are maximum capabilities, expansible from a minimum system. You buy a system tailored to your exact requirements.

Add to this versatile equipment the computer systems engineering ability demonstrated by General Electric in implementing these twenty GE-312 system applications.

Add also the long history of General Electric overall systems know-how—its broad background in the equipment, processes and materials to which you apply computer control.

Tomorrow's profits will come from today's combination of vision, equipment, and know-how. *Where do you stand?*

There are General Electric Sales and Application engineers in over one hundred offices throughout the nation to serve you. *Phone* the nearest General Electric Apparatus Sales Office, or *wire* General Electric Computer Department, 13449 North Black Canyon Highway, Phoenix, Arizona.

PROCESS CONTROL
AUTOMATED BY GENERAL ELECTRIC

Progress Is Our Most Important Product

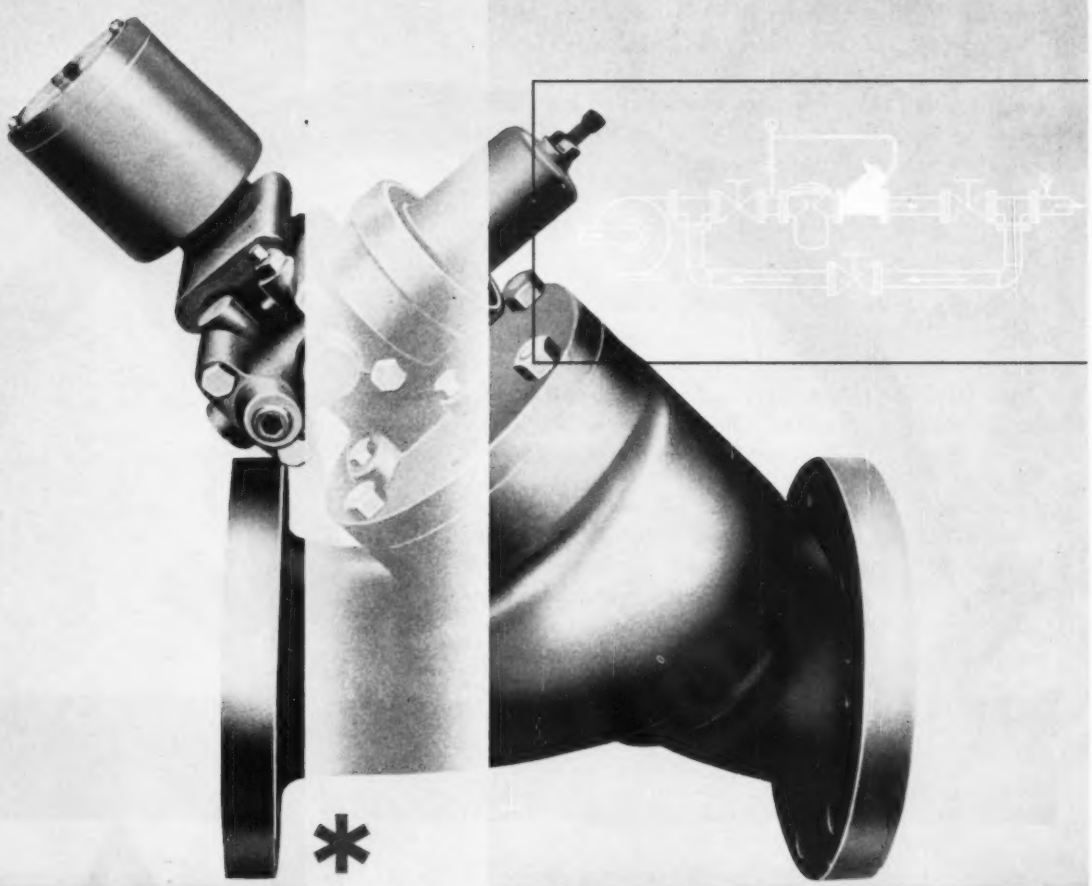
GENERAL ELECTRIC

CPA-150 (9-60)

General Electric—a pioneer in computer systems for all phases of business, industrial, scientific, engineering, and financial endeavor.

Complete Adaptability

You name the application *
BRODIE Series 500 Control Valves are adaptable to fit it!



One valve does many jobs by simply changing pilots or adding multiple pilots, which are integrally mounted (**as shown above**). Smooth responsive control of extreme variations in flows and pressures with minimal pulsations is effected by **standardized** linear characteristics, large internal pilot valve ports, uniform rate of response. Self-contained internal parts, **including seat ring** are easily removed as a single cartridge unit. **For full details write for Bulletin 668, today.**

- Remote Control
- Diff. Pressure
- Rate of Flow
- Pressure Relief
- Pressure Regulation
- Surge Control
- Check Valve
- Thermal Pressure Relief
- Safety Shut-off

BRODIE
VALVES · METERS

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REPRESENTATIVES WITH STOCKS AND SERVICE FACILITIES IN ALL PRINCIPAL CITIES

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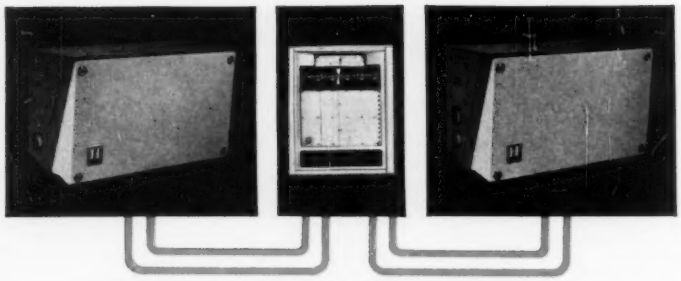


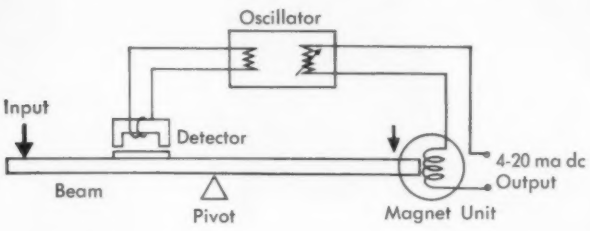
***ElectriK Tel-O-Set*—the true 2-wire system**

Care and feedback of delicate inputs

Delicate inputs thrive on the tender care of *ElectriK Tel-O-Set's force-balance feed'ack system*. This system, used as the basic circuit in *Tel-O-Set* transmitters, receivers, controllers, and other instruments, has proved itself in thousands of installations in the last five years. The force-balance feedback circuit increases the accuracy and dynamic response of the system by decreasing hysteresis effects and sensitivity to changes in ambient conditions.

Observe: (1) input force (from bellows, Bourdon tube, or displacement linkage) deflects pivoted beam; (2) air-gap in ferrite detector increases, (3) producing a change in inductance in oscillator circuit; (4) a portion of output current is fed back into magnet unit, producing a force on beam which is equal and opposite to input force; feedback balances beam. Full scale motion is only one-thousandth of an inch.

The advanced control engineering seen in force-balance feedback is carried through the entire *ElectriK Tel-O-Set* System. Specifically, there's no external power required at any field-mounted *Tel-O-Set* instrument. Line power connection is made only at the receiver. Two-wire d-c transmission eliminates shielding problems. The 4-20 milliamp signal range of the system gives a live zero and permits the use of the most reliable transistors available. The d-c signals



can be fed into data handling systems and millivolt-actuated instruments . . . can be easily transduced to a standard 3-15 psi pneumatic signal to operate existing pneumatic systems.

Take a new look at your control applications with the *ElectriK Tel-O-Set* System in mind! Get complete technical data from your local Honeywell field engineer. Call him today . . . he's as near as your phone. MINNEAPOLIS-HONEYWELL, 21 Penn Street, Fall River, Massachusetts.

Honeywell

First in Control

SINCE 1885

75th YEAR

PIONEERING THE FUTURE

For more data on advertised products, use Readers' Service Cards, last page.

POWELL

WORLD'S LARGEST FAMILY OF

VALVES

performance makes the world of difference

POWELL PETROLEUM VALVES

Powell valves are performance-proven with 100 years of service to the oil industry. Powell offers valves in the greatest variety of sizes, designs, pressures, and metals to handle almost *every* flow control requirement of *every* industry. Contact your nearest Powell distributor. Or write to us. Our engineers and metallurgists are at your service to solve your valve problems!

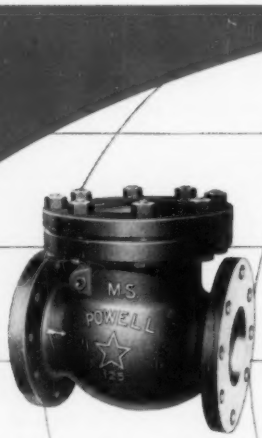


Fig. 559—Large iron body bronze mounted swing check valve for 125 pounds W.P. Bolted flanged cap. Regrindable, renewable bronze seat and disc.

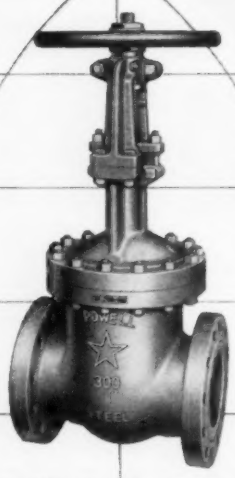


Fig. 3003—Flanged end steel gate valve for 300 pounds W.P. Outside screw rising stem and yoke.

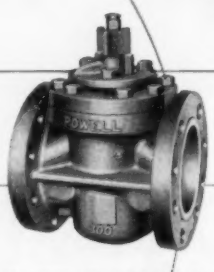


Fig. 3059—Steel lubricated plug valve. ASA 300 pounds. Bolted gland type. Also available with screwed ends—Fig. 3058.

THE WM. POWELL COMPANY • DEPENDABLE VALVES SINCE 1846 • CINCINNATI 22, OHIO

THE COMPLETE LINE TO TAKE CARE OF ANY KIND OF PIPE MOTION

Flexonics has the equipment—as well as the experience and the skill—to take care of any kind of pipe motion problem. Here's where you benefit from more research . . . more metallurgical care . . . more service . . . and now standard stock sizes for quick delivery. They all add up to expansion joints that you can *install and forget*—plus expansion compensators, flexible connectors, and the all-new Flexonics pipe alignment guides and roller pipe supports—to take care of any kind of pipe motion!

Today—mail the coupon for your copy of the Flexonics Expansion Joint Engineering Guide No. 222-A. It's new! 28 pages of valuable information.

Member Expansion Joint Manufacturers Association

EJ-238-R

Flexonics
corporation

In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ont.

EXPANSION JOINTS · METAL HOSE · SYNTHETIC HOSE · BELLOWS · AERO/SPACE COMPONENTS

SUBSIDIARY OF CALUMET & HECLA, INC.

ATTACH TO YOUR LETTERHEAD—MAIL TODAY!

Flexonics Corporation
1336 South Third Avenue
Maywood, Illinois

Please rush me complete information on

- ☐ Expansion Joints
- ☐ Expansion Compensators
- ☐ Flexible Connectors
- ☐ Pipe Guides and Supports

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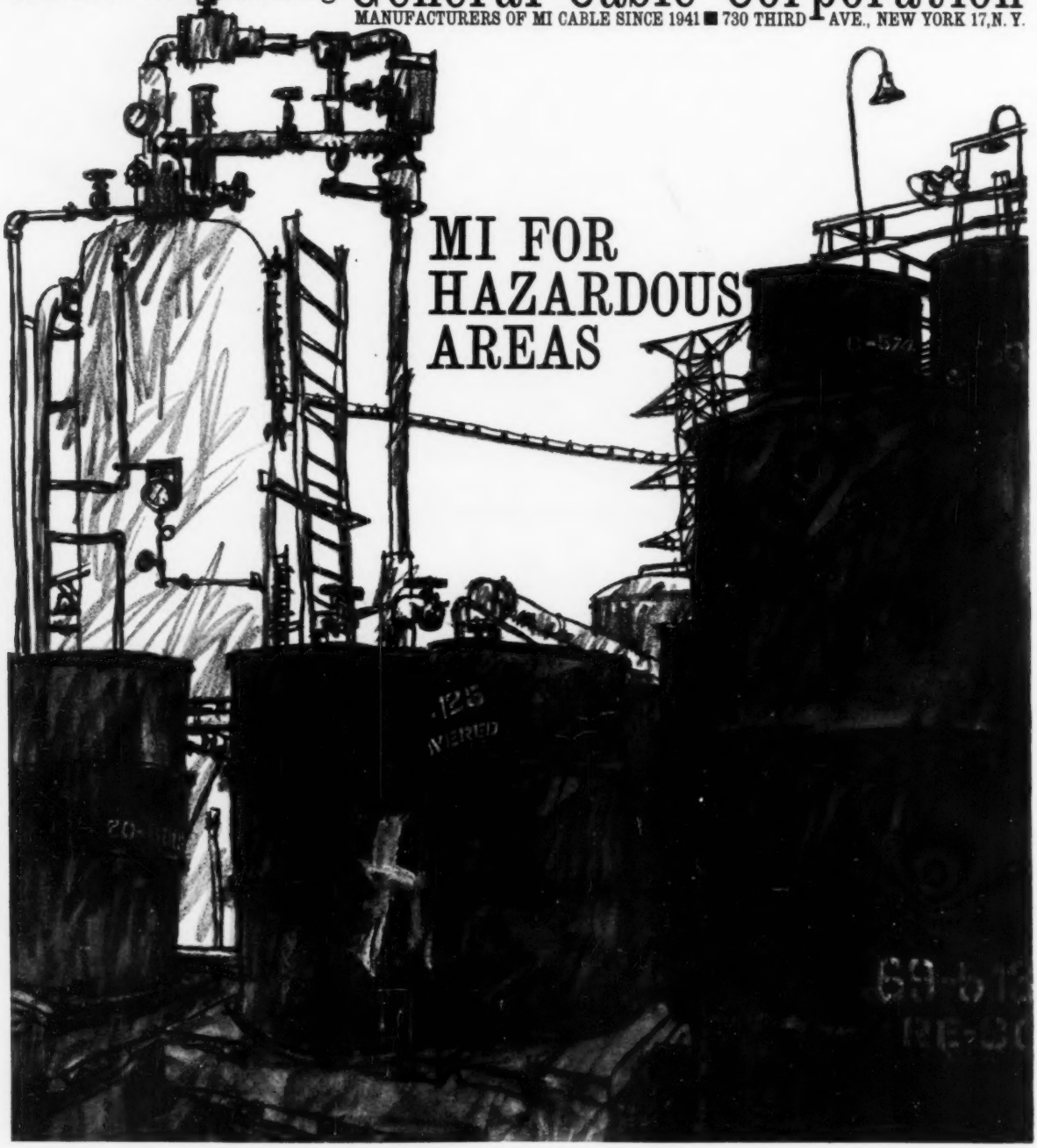
Oil companies throughout the country specify Safety MI Cable for hazardous applications and for remote control and instrumentation. Outstanding design engineers recommend it. One four-part reason... MI's exceptional record of safety, efficiency, permanence and economy. ■ Investigate the many unique characteristics of this versatile cable construction by writing for the new MI catalog

General Cable Corporation

MANUFACTURERS OF MI CABLE SINCE 1941 ■ 730 THIRD AVE., NEW YORK 17, N. Y.

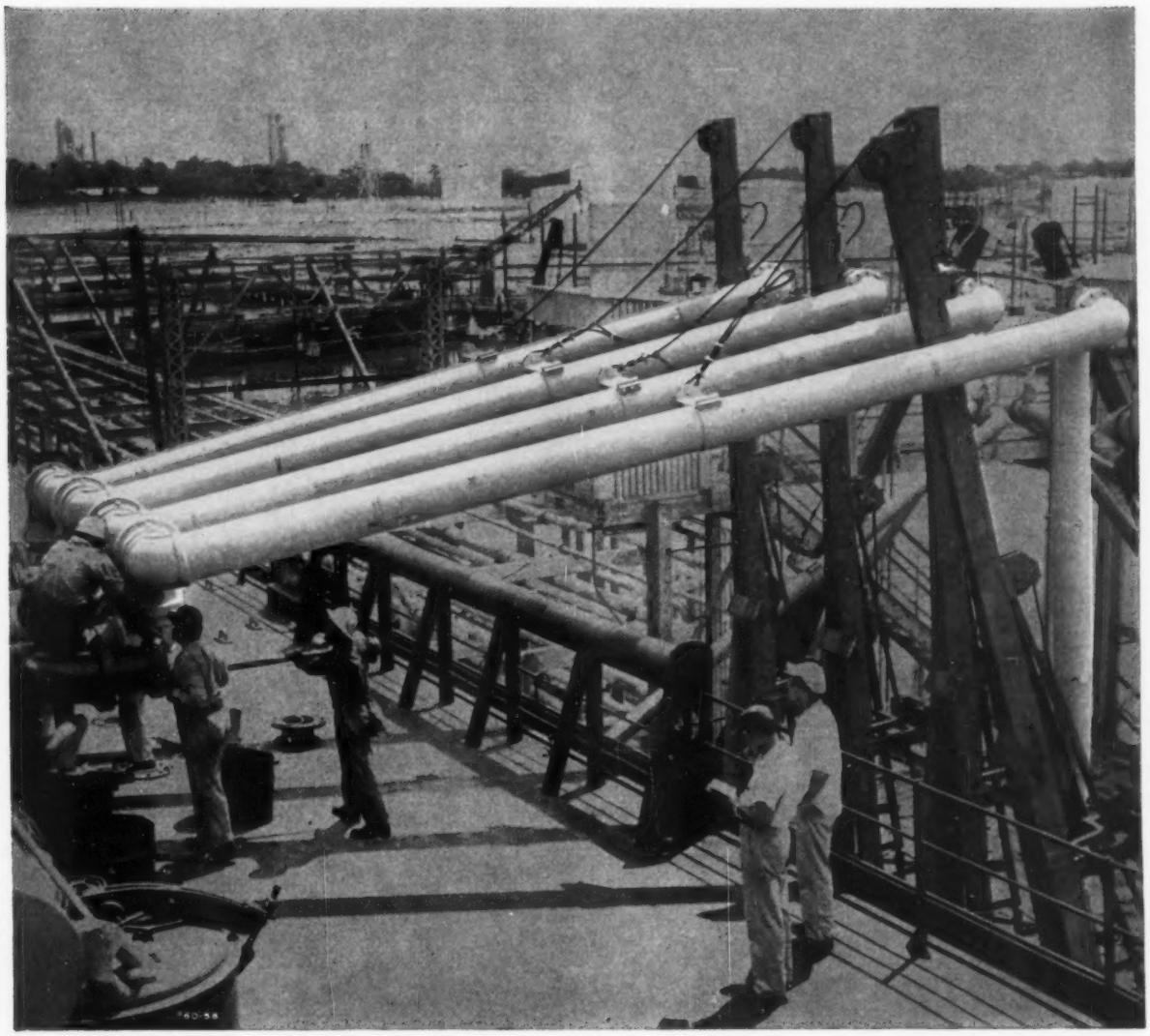


PROOF OF PERFORMANCE at a major gulf coast refinery.

Nothing says customer satisfaction as strongly as a re-order. Since Chiksan sold its first Hydraulic Marine Loading System in 1955, many original customers have re-ordered. They have learned through actual operation that this is the safest, most efficient, most practical method of modern tanker loading. The Chiksan system shown went into service in September, 1959; additional units have since been ordered. For a quotation on a system for your terminal, write Chiksan, Brea, California.

Inc. CHIKSAN

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION



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NALCO'S OWN POPULATION BOOM...

(in Water Treatment Skills and Experience)

These are the Nalco people in the background* when a Nalco Representative tackles your water treatment problem. He can call on any or all of them when necessary . . . and the specialized skills and experience they have are strong support for his own expert knowledge of water treatment chemicals—and how plants should use them.

Nalco's population boom in water treatment skills and experience is simply further assurance that when you want water treatment *results* your Nalco Representative is the man to call.

**The technically trained headquarters people who conduct research and customer service work on every kind of water treatment problem.*

NALCO CHEMICAL COMPANY

6259 West 66th Place • Chicago 38, Illinois

Subsidiaries in England, Italy, Mexico, Spain, Venezuela and West Germany
In Canada: Alchem Limited, Burlington, Ontario

Nalco® . . . Serving Industry through Practical Applied Science

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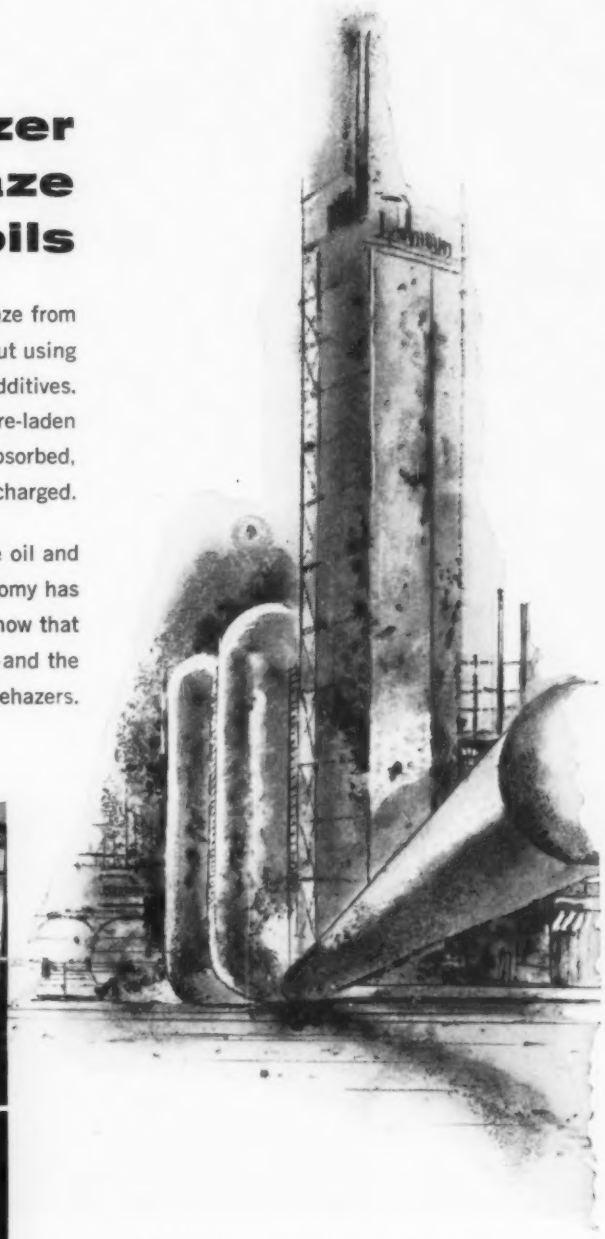
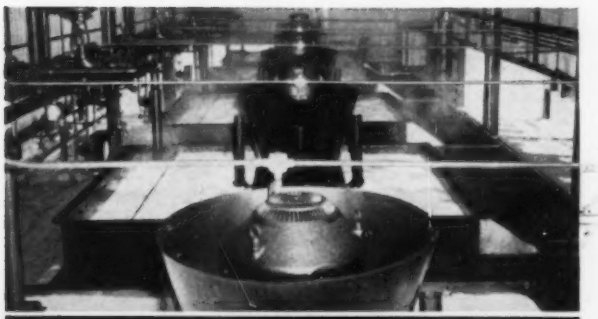
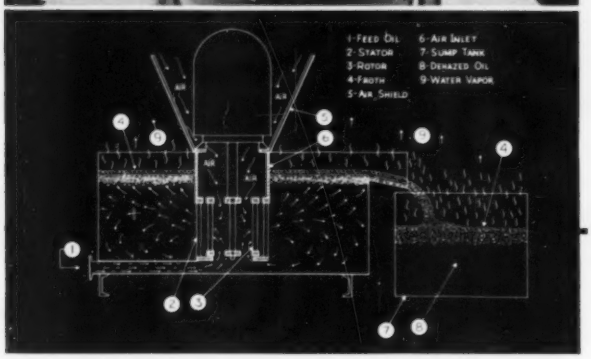
Hendrick dehazer lifts the haze from refinery oils

The Hendrick Hydro-Dehazer removes haze from refinery oils quickly and economically, without using compressed air, high heat, chemicals or other additives. The Hydro-Dehazer's huge rotor mixes moisture-laden oil with free air until the moisture is absorbed, rises to the top, and is discharged.

Produces bright, haze-free furnace oil and diesel fuel at 400 B.P.H. Economy has been proven in installations which show that Hendrick has the most efficient method—and the lowest operating cost—of all dehazers.







Hendrick will be glad to arrange a free demonstration. For details, mail this coupon today.

HENDRICK MANUFACTURING COMPANY
36 Dundaff Street, Carbondale, Pennsylvania

Gentlemen: I am interested in learning more about the new Hendrick Hydro-Dehazer.

☐ Please arrange demonstration of the Dehazer Pilot Model.

☐ Please send technical data.

NAME_____ TITLE_____

COMPANY_____

STREET ADDRESS_____

CITY_____ STATE_____

Hendrick
Manufacturing Company
Carbondale, Pennsylvania

PERFORATED METAL · PERFORATED METAL SCREENS · WEDGE-SLOT AND HENDRICK WEDGE WIRE SCREENS · ARCHITECTURAL GRILLES MITCO OPEN STEEL FLOORING · SHUR-SITE TREADS · ARMORGRIDS HENDRICK HYDRO DEHAZER · DISTILLATION COLUMN INTERNALS FLUIDIZED BED PERFORATED PLATES AND GRIDS

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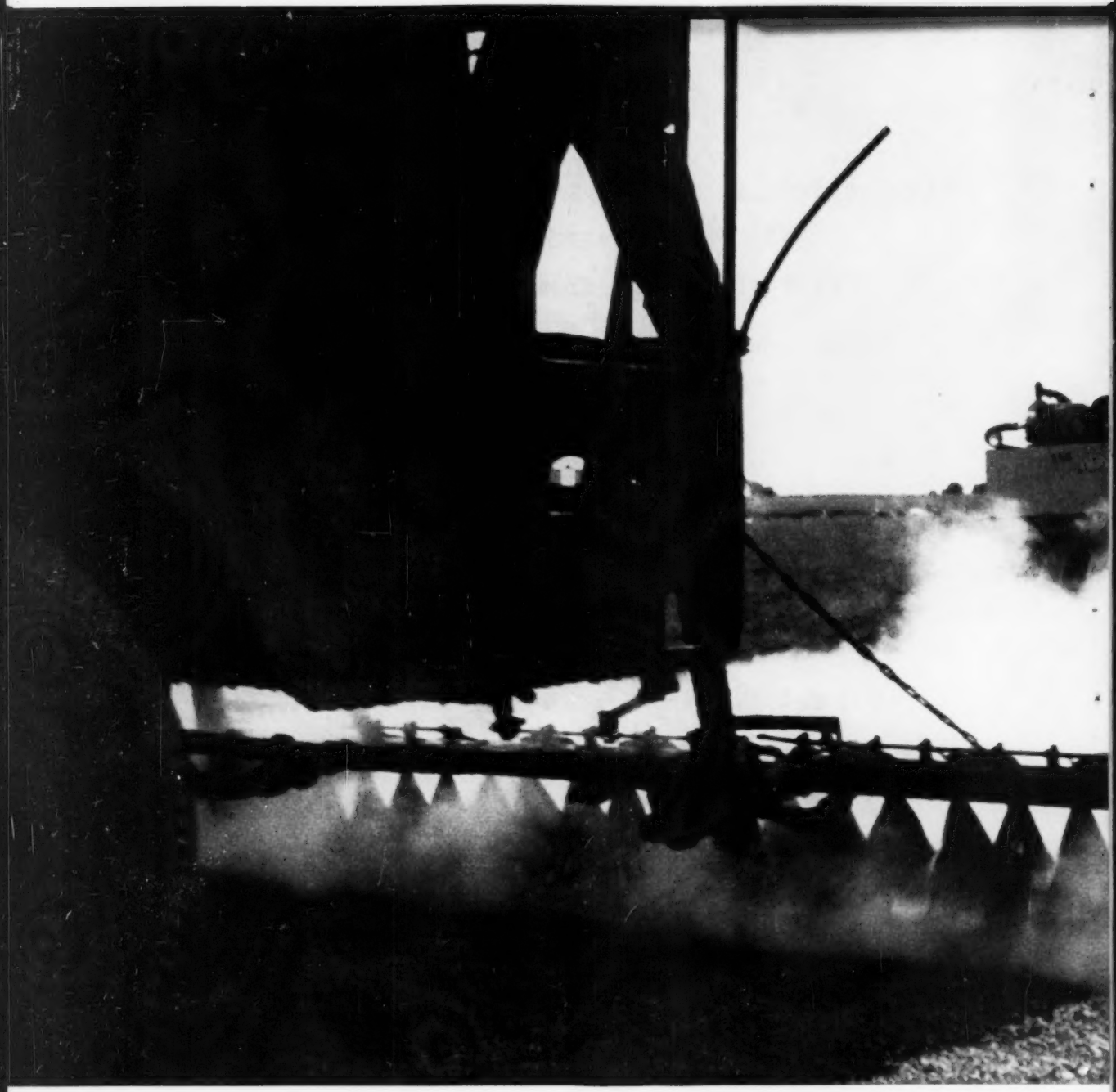


Proving the improvements in

The highway re-paving crew above is laying a section of state road that will add another page of field test results and data in the growing file on Armour's road construction chemicals.

Since Armour first developed chemicals for improving asphalt paving, Armour research men have been constantly at work proving the improvements. This testing aided development of two groups of outstanding paving chemicals; **Redicote**® compounds, anti-stripping agents for asphalt cements and cutbacks; Armour *Cationic* Asphalt Emulsifiers for emulsified asphalts.

REDICOTES—Armour Redicotes improve adhesion of asphalt onto any aggregate. Redicotes make every kind of weather good asphalt-paving weather. No wait for drying after a rain . . . no wait for morning dew to dry. Redicotes are economical because it takes so little to do a job. In some cases as small a concentration as 0.2% will give complete coating and insure anti-stripping properties. Armour Redicotes offer additional satisfaction with guaranteed uniformity in batch after batch. Redicotes . . . make asphalt adhere better . . . cost less and are quality controlled.

Armour road construction chemicals

ARMOUR'S CATIONIC ASPHALT EMULSIONS—Armour cationic emulsifiers ionize in solution to give positively charged particles. The "break" of these cationic asphalt emulsions may begin to take place the moment of contact or may be delayed to suit particular requirements. Surface or atmospheric conditions have little effect on the break or the adherent properties of the emulsified asphalt. The bond is such that it displaces water on the surface and prevents stripping. Emulsions made with Armour cationics give you: controlled break-time . . . ease of emulsification . . . built-in anti-stripping.

As testing continues and new improvements are found, they will be subjected to the same rigid tests that have made Armour chemicals highly efficient and economical.

For additional information about these road construction chemicals, talk to Armour's chemical specialists or write for samples and these booklets: "Redicotes," "Armour Cationic Asphalt Emulsions."

ARMOUR INDUSTRIAL CHEMICAL COMPANY
© DIVISION OF ARMOUR AND COMPANY
110 North Wacker Drive, Chicago 6, Illinois

parallel construction

DEKORON®

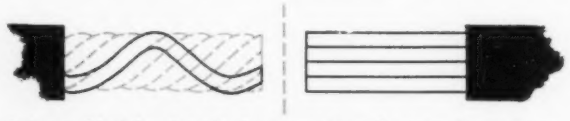
NEW METL-COR

now with number coding

Dekoron New Metl-Cor is an exciting instrument harness design that simplifies and speeds installation of tubing... makes neater and tidier tubing installations — because New Metl-Cor, with exclusive parallel-tube construction, is now number-coded every 2 inches.

That means there's no delay caused by trial-and-error compressed-air testing of lines. Follow the number code and hook-up correctly the first time. There's no untwisting of corkscrew tubes. Peel the sheath back and connect straight lines fast. Dekoron New Metl-Cor also features an improved polyethylene sheath for maximum corrosion and impact protection and proven Dekoron quality — all at no increase in price.

Tube up with the best... it costs you less. Tube up with Dekoron products — instrument-engineered by instrument engineers. A-3058A

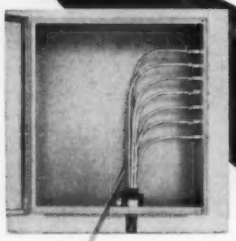


Dekoron Metl-Cor installs in record time-because it needs no straightening, bends readily . . . has no "low spots, moisture traps."

Lengths
TO 1000 FEET

Greater Resiliency
IMPACT PROTECTION

Improved Polyethylene
GREATER CHEMICAL RESISTANCE



Number Coding
INSTALLS FASTER

Parallel Tubes
NEATER TAKEOFFS

Core Tubes
COPPER OR ALUMINUM

Dekoron products

quality • research • service

SAMUEL MOORE & COMPANY • DEKORON PRODUCTS DIVISION • **MANTUA, OHIO**

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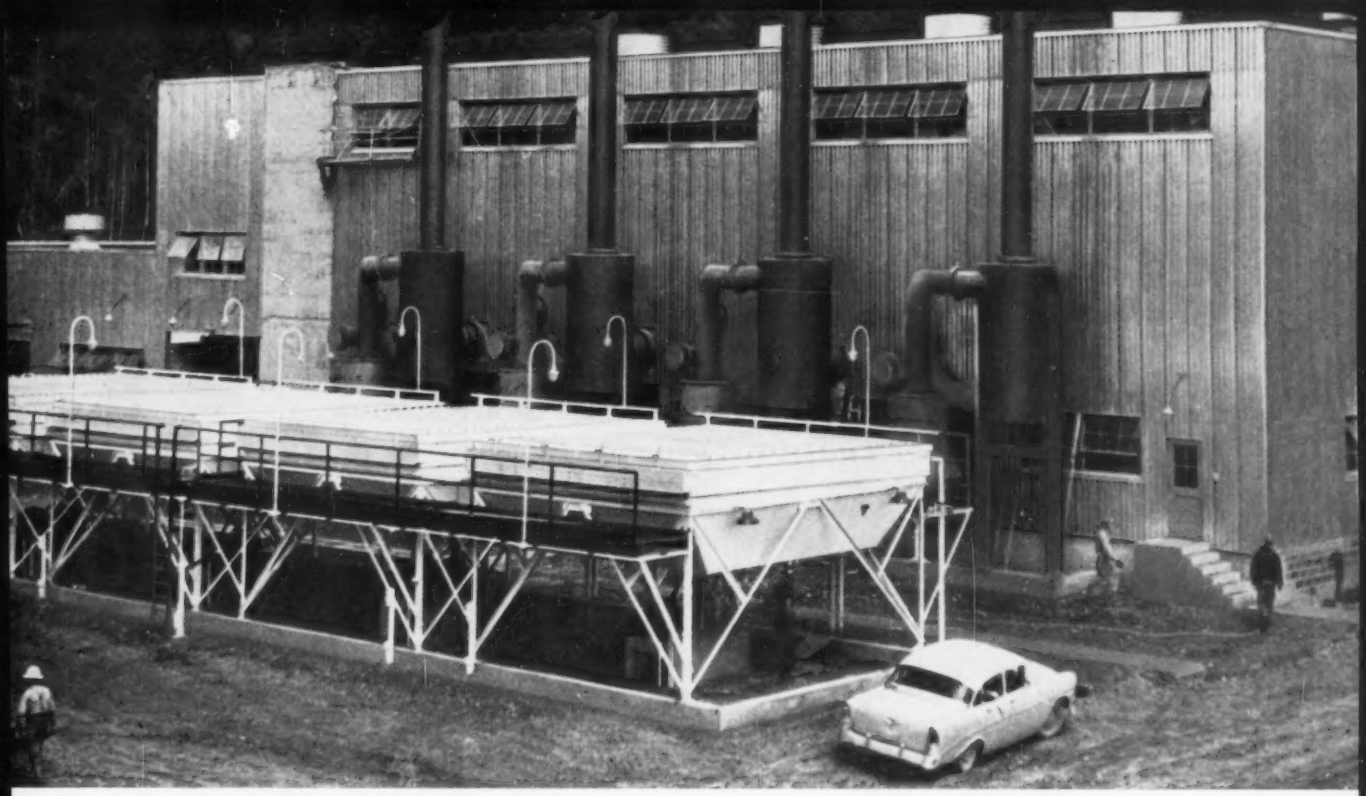


Twenty air cooled units like this cool engine jacket water for four Canadian "Big Inch" compressor stations. Units are designed to dissipate 8.6 MBTU/hr. from the 288 gpm jacket cooling water at temperatures from 170 to 110° with an ambient temperature of 90° F. General contractor: Canadian Bechtel, Ltd.

Canadian "Big Inch" cools jacket water with Trane Fluid Coolers - at 35° below!

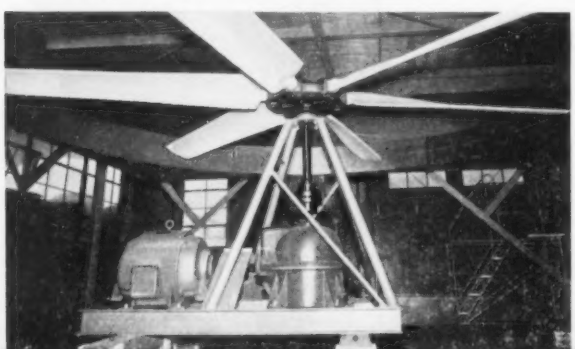
Westcoast Transmission Company's 650 mile-long, 30-inch pipeline system through British Columbia passes through country where winter temperatures are very low. Cooling engine jacket water for compressor stations along the way takes rugged equipment—coolers that can function efficiently at 35 or 40 degrees below zero.

Westcoast Transmission Company chose TRANE Fluid Coolers for this important job. Air cooling was essential at these extreme temperatures. And TRANE Fluid Coolers have shown that they meet exacting requirements under all weather conditions.

More and more major transmission companies are turning to TRANE for rugged, dependable Fluid Coolers. Many of these companies report simplified maintenance, a minimum of adjustment problems. And, with TRANE Fluid Coolers, engineers know that they can depend upon the accuracy and completeness of the capacity ratings—based upon the industry's most complete laboratory testing.

When you have a fluid cooling problem, turn to TRANE! Call your nearby TRANE Sales Office. Or write TRANE, La Crosse, Wisconsin.

The air handling segments have shutters for control of their forced vertical air flow, with variable-pitch propellers. (TRANE Fluid Coolers are also available with horizontal discharge.) 2-speed fan, motor and drive are factory-aligned on a single metal base. All framework parts are predrilled and match-marked.



For any air condition, turn to

TRANE

MANUFACTURING ENGINEERS OF AIR CONDITIONING, HEATING, VENTILATING AND HEAT TRANSFER EQUIPMENT

THE TRANE COMPANY, LA CROSSE, WIS. • SCRANTON MFG. DIV., SCRANTON, PA. CLARKSVILLE MFG. DIV., CLARKSVILLE, TENN. • TRANE COMPANY OF CANADA, LIMITED, TORONTO • 100 U.S. AND 19 CANADIAN OFFICES

take NEWTHERM on test!

Test its STRENGTH

NEWTHERM is unusually strong and rigid—a feature of special importance in the larger, more vulnerable sections. Put a sample section or slab on part of your plant and *prove for yourself* its outstanding ability to withstand impact and water damage. See how it withstands rough handling in transit and erection, minimising breakage in shipment and erection by unskilled labour at the most remote sites.

Test its MOISTURE RESISTANCE

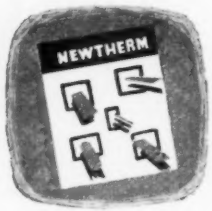
Even totally immersed in water, NEWTHERM retains much of its strength and rigidity. It does not become deformed when in contact with water, thus work-in-progress need not be covered. Especially on contracts where weather conditions would delay the application of insulation – NEWTHERM is the material to use.

Test its LIGHTNESS

Unusually light for such a high-efficiency material, NEWTHERM compares favourably in this respect with other insulants far inferior in strength. That means easier handling and fewer breakages—even the largest section is easily carried in one hand.

Test its EASE OF APPLICATION

Undoubtedly, NEWTHERM is one of the easiest of materials to apply. It is supplied in plastic form and in a wide range of standard-sized sections and slabs, smoothly finished and straight edged for immediate fitting. The finished job is very neat, with minimum joints, and appliers particularly appreciate the handleability of the material - especially in difficult situations.



READ ALL ABOUT NEWTHERM

in a specially prepared booklet. Sizes, compressive strength, thermal conductivity,—this and much more useful information can be on file if you write for your copy now, to the sole manufacturers Newalls Insulation Co. Ltd.

NEWALLS (Reg'd Brand)

***NEWTHERM** calcium silicate insulation*

. . . for temperatures up to 1400°F.

NEWALLS INSULATION CO. LTD.

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A member of the TURNER & NEWALL ORGANISATION
Offices & Depots at: LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE, BIRMINGHAM, BELFAST, DUBLIN, BRISTOL & CARDIFF.
Agents and Vendors in most markets abroad.

59

How much does your finned tube dollar buy?

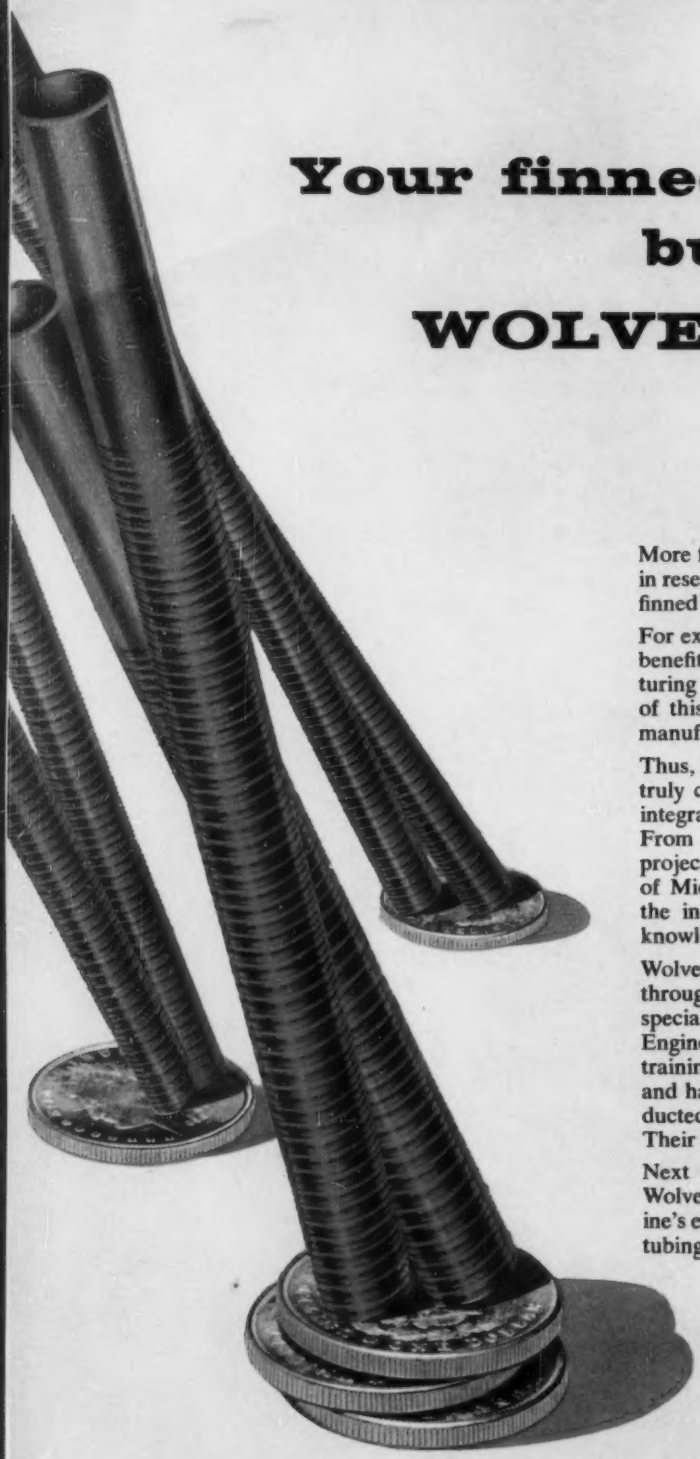
The answer is plenty—particularly when you buy Wolverine Trufin® Type S/T, the original, integrally finned tube.

Wolverine Tube developed this type of tubing and over the past 20 years has brought Wolverine Trufin Type S/T to a high degree of perfection. Through constant research and testing plus actual "on-the-job" data gathered from countless installations, it has proved the many money-saving ways in which this extended-surface tubing can help you.

FOR EXAMPLE:

- Type S/T has more than 2½ times as much outside surface area as a comparable piece of plain tube
- More surface area means more BTU's per foot of tube thus requiring fewer tubes to transfer a given heat load
- Fewer tubes means smaller shells, headers, baffles, etc.
- Less weight of tube metal to transfer a given heat load
- Lighter units require less structural support
- Integral fins are unaffected by vibration, thermal shock, or pressure variations
- Interchangeable with plain tube
- Available in complete size ranges in copper, copper alloys, aluminum and steel

Ask your Wolverine sales representative for complete information about Wolverine Trufin Type S/T. Write, too, for a free copy of the Trufin Design and Cost Comparison Book.



Your finned tube dollar buys more from WOLVERINE TUBE

More for your money . . . in products . . . in services . . . in research and development . . . these are the things your finned tube dollar buys at Wolverine Tube.

For example, *only* from Wolverine Tube can you get the benefits of more than 20 years of finned tube manufacturing experience. Wolverine is the original producer of this type of tubing — for many years was the sole manufacturer.

Thus, it is *only* from Wolverine Tube that you can obtain truly competent guidance concerning the proper use of integrally finned tubing in heat transfer applications. From its own research facilities, and from research projects carried on in conjunction with the University of Michigan, Wolverine has, over the years, compiled the industry's most comprehensive file of finned tube knowledge.

Wolverine makes this information available to you through its literature and through its staff of heat transfer specialists. These men—members of the Wolverine Field Engineering Service — have all undergone intensive training in finned tube technology in Wolverine plants, and have completed a process heat transfer course conducted by Dr. Donald Q. Kern, Wolverine consultant. Their services are yours at any time—without obligation.

Next time you specify integrally finned tube, consult Wolverine Tube before placing your order. Let Wolverine's experience help you obtain maximum value for your tubing dollars.

WOLVERINE TUBE
DIVISION OF
Calumet & Hecla, Inc.
DEPT. F, 17236 SOUTHFIELD RD., ALLEN PARK, MICH.
Manufacturers of Quality Controlled Tubing

Wolverine Trufin is available in Canada through the Unifin Tube Division, London, Ontario.

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES.

A "quick open" package for insulation products...

"K&M" TEAR-TAPE CARTON

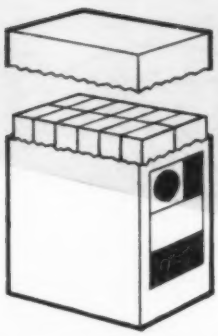
Opens neat and easy... like a coffee can lid!

Easy does it . . . with the new "K&M" "Tear-Tape" Carton. Just pull the tab on the front panel. The top of the carton comes off cleanly and easily. No strain! No stress! No time and energy wasted! Your "K&M" KaytherM Block Insulation is open and ready to use in seconds.

Keep an eye on K&M! This is only one of a stream of exciting ideas on new products and customer service pouring out of K&M! Write today for more information on the new "Tear-Tape" Carton to: Keasbey & Mattison Company, Ambler, Pa. Dept. I-1100.

- Pull tab.
- Strip of board peels off like band of tin around top of coffee can.
- Whole lid lifts off for easy access to "K&M" KaytherM Block Insulation.

K·M
BEST IN ASBESTOS



Keasbey & Mattison at Ambler

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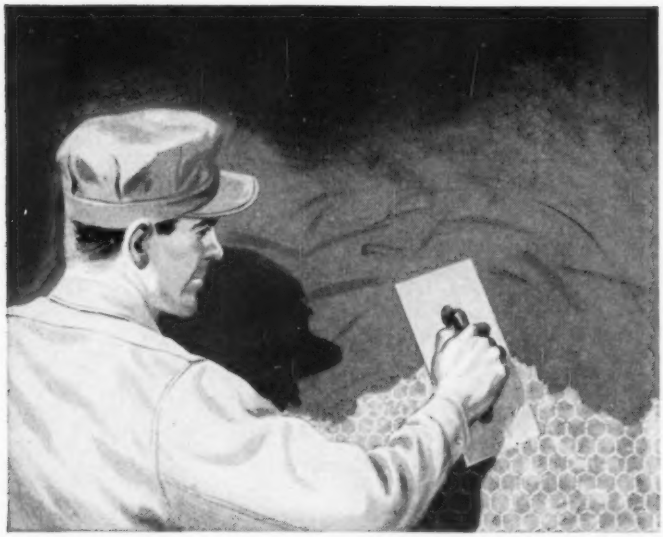
U. S. STEEL reports:

SMALL VALVE IN 4TH YEAR OF 'ROUND-THE-CLOCK' SERVICE!

It guards the outlet of one of the world's largest acid tanks for U. S. Steel. Here are the performance facts on this 4" Aloyco Gate Valve (made of Aloyco 20 Stainless Steel): It still shuts off tight. It has required no servicing except for minor packing adjustment. It has been on continuous 24-hour service for 4 years. People who pay for performance only, rely on Aloyco Stainless Steel Valves wherever corrosion is a problem. Want a safe, economical way to handle corrosives? Write: Alloy Steel Products Co., Inc., **1303** West Elizabeth Ave., Linden, New Jersey. 03

ALLOY STEEL PRODUCTS COMPANY

Boston • New York • Wilmington • Atlanta • Birmingham • Baton Rouge • Buffalo • Pittsburgh • Chicago • St. Louis • San Francisco • Los Angeles • Seattle



You get 20% MORE COVERAGE

with EAGLE-PICHER SUPER "66" insulating cement

for temperatures up to 1800 F.

Because Super "66" Insulating Cement gives you less shrinkage (volumetric shrinkage wet to dry only 18½%), you get up to 20% greater dry coverage (50-55 bd. ft. per 100-lb.), with uniform thickness for better protection and strength. Result: You save warehouse space, time and labor costs.

Eagle-Picher Super "66" Insulating Cement *sticks to hot or cold surfaces.* It contains a special rust inhibitor that actually *prevents corrosion.* In addition Super "66" is easy to apply . . . reclaimable when used to 1200 F . . . and offers one of the most effective thermal barriers known. Super "66" can be applied on irregular shapes and usually requires no reinforcing on applications up to 1½ inches thick.

Eagle-Picher produces a line of industrial insulations for all temperatures from below zero to over 2000 F. See our complete catalog in Sweet's Plant Engineering File or write for descriptive material.

Since 1843

EAGLE EP PICHER

EAGLE-PICHER

The Eagle-Picher Company • General Offices

Dept. PR-1060 • Cincinnati 1, Ohio

Member of National Insulation Manufacturers Association

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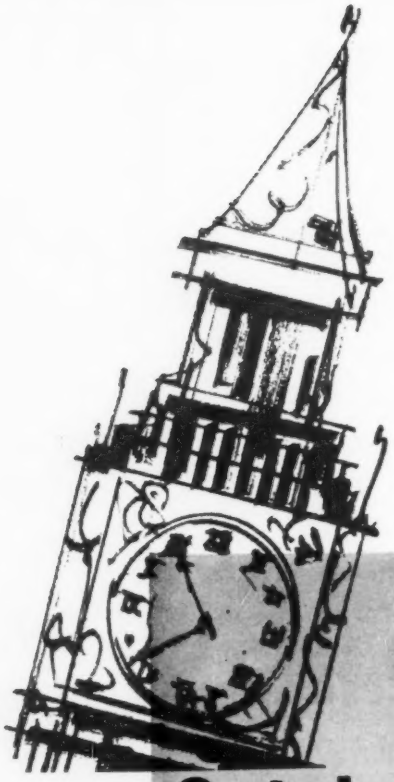
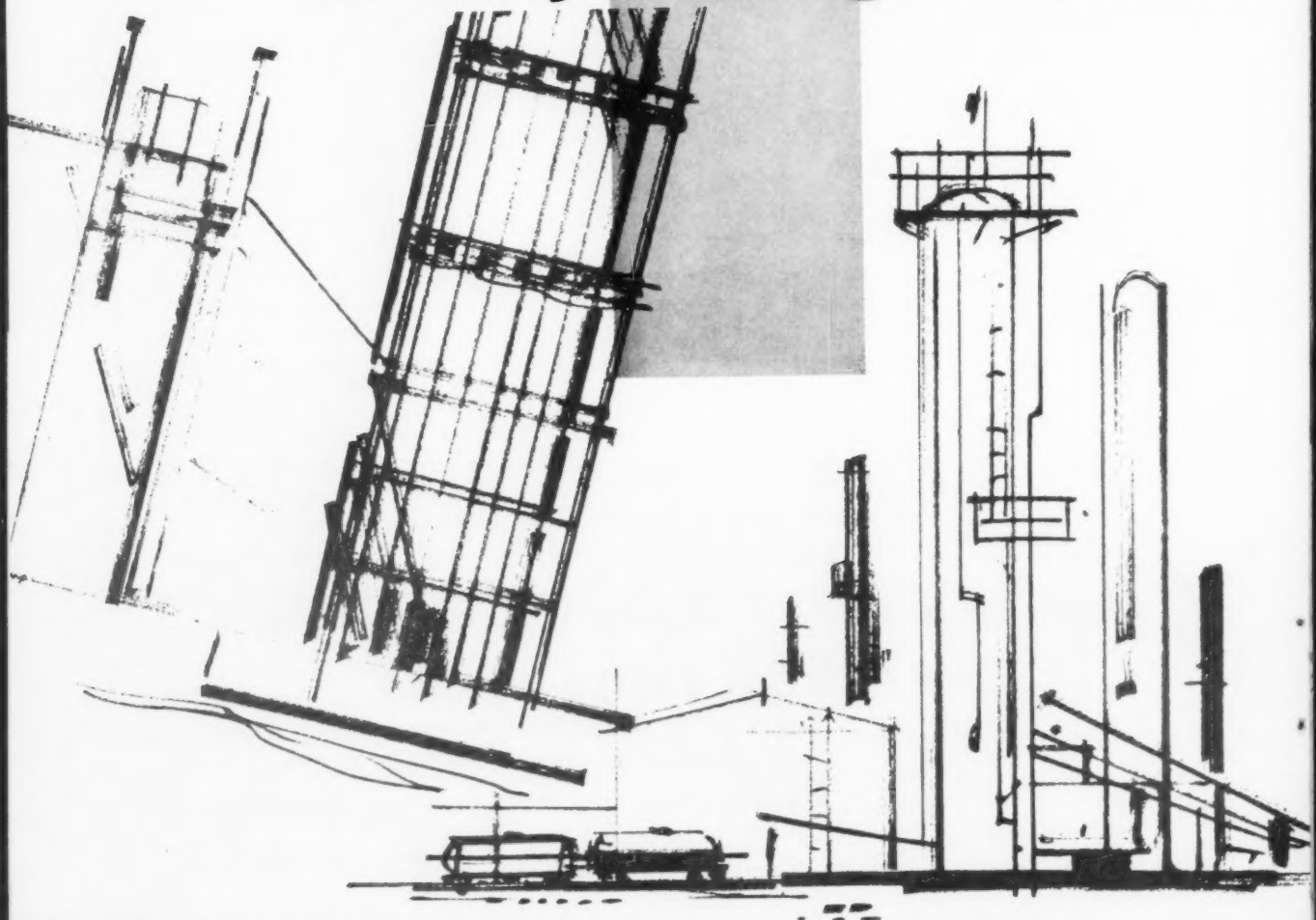


Refinery Catalog is awake .



Like the refining and petrochemical industry, REFINERY CATALOG never shuts down. Through this exclusive industry buying handbook, more than 300 manufacturers and service companies maintain representatives at your side 24 hours a day, throughout the year.

In REFINERY CATALOG, you have – as near as your desk – complete or condensed catalogs describing in detail thousands of products and services used by the oil, gas and petrochemical processing industry.

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World's Largest Specialized Publisher to the Oil Industries

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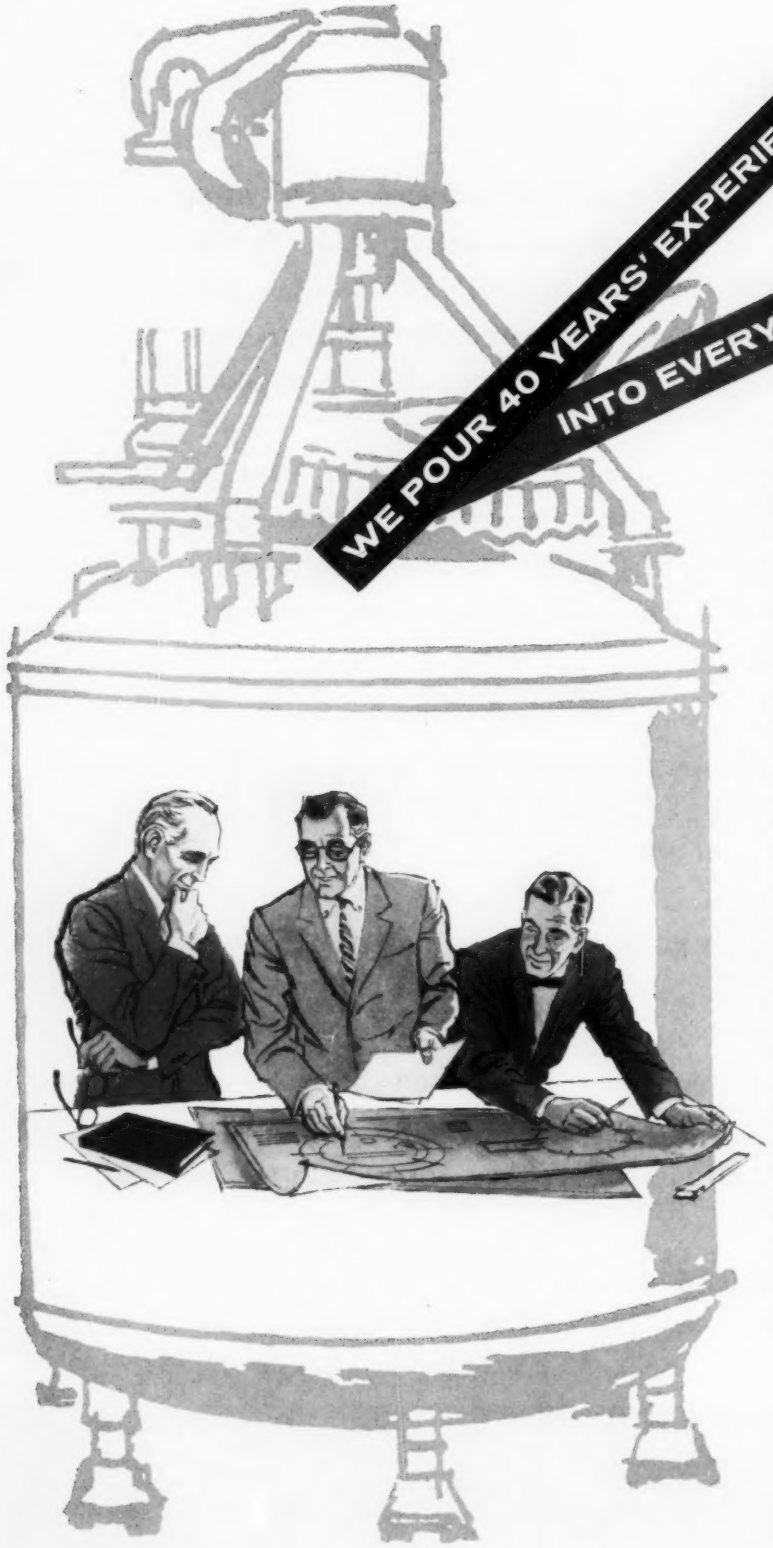


WE POUR 40 YEARS' EXPERIENCE INTO EVERY GLASCOTE VESSEL

Behind every Glascote glass-lined product is an experienced sales engineer who can give you on-the-spot product and process assistance. And behind him, there are 40 years of Glascote experience in manufacturing glass-lined vessels and tanks for the petroleum and chemical industries.

Through continuous research and development engineering, Glascote stays ahead of the demand for new and improved processes requiring a wider range of corrosion, temperature and thermal shock-resisting properties for glass linings. For example, new Glascote 778 is the most corrosion-resistant glass ever applied to chemical and petroleum processing equipment — this without sacrificing any other protective property.

Glascote and its parent organization, A. O. Smith Corporation, have developed more than 3000 glass formulas — the best of these giving you superiority in glass-lined reactors, columns, storage tanks, rotary dryer-blenders, pipe and fittings. For additional information, ask your Glascote representative for specific product data. Or write direct: Glascote Products, Inc., Cleveland 17. Ohio.

Through research ... a better way

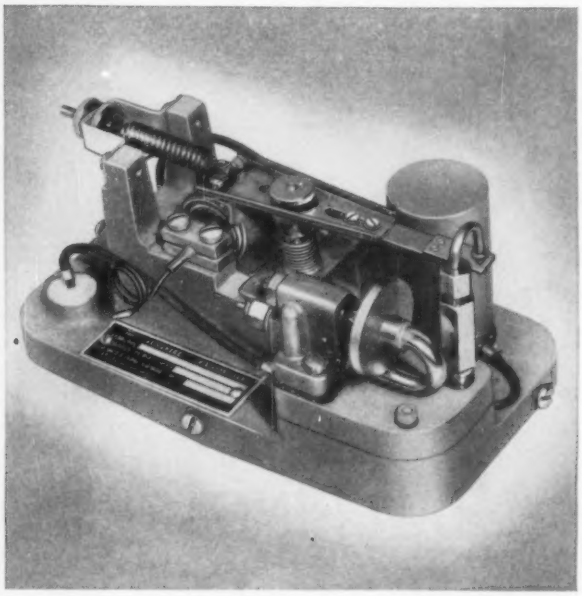
A.O.Smith
CORPORATION

Subsidiary: GLASCOTE PRODUCTS, INC.

REACTORS · SPHERICAL REACTORS · COLUMNS · STORAGE TANKS · HEAT EXCHANGER TUBES · ROTARY DRYER-BLENDERS · PIPE AND FITTINGS

The compact SENSAIRE Transmitter *measures only 7¾" x 4¾" x 4¼". Weighs only 7 lbs. Suitable for many types of application.*

Interchangeable, all-welded thermal system. *Bi-Metal case compensation. Especially desirable on low temperature applications and where mercury is not acceptable.*



New from Taylor... GAS-ACTUATED SENSAIRE* TRANSMITTER

This new version of the time-proven SENSAIRE Transmitter makes low-cost temperature measurement available for those applications where mercury actuation is not acceptable. A force-balance type transmitter, No. 202TG is compact, sturdy and extremely dependable. Adjustments are simplified; repeatability is excellent.

- **Available in 3 range spans.** 100°F., within limits of minus 400°F. to +300°F.; 200° and 400°F, within limits of minus 400°F. to +1000°F.
- **Maximum overrange protection**—100% of range span above operating range.
- **Calibration accuracy** within 1% of range span below 550°F.; 1½% above 550°.
- **Ambient case temperature limits**—minus 30° to +150°F.
- **Air supply**—20 psi recommended; 25 psi maximum.
- **Air consumption**—0.4 scfm.
- **Bulb size**—11/16" x 5⅛". (Optional capillary bulb gives temperature averaging effect. Permits variable immersion with no loss of accuracy.)

Ask your Taylor Field Engineer, or write for **Bulletin 98293.** Taylor Instrument Companies, Rochester 1, New York, and Toronto, Canada.

Easy to install. *Mounts in any position. Universal bracket provides for direct mounting on pipe, wall or wrench head of well or separable bushing.*

*Trade-Mark

Taylor Instruments **MEAN ACCURACY FIRST**

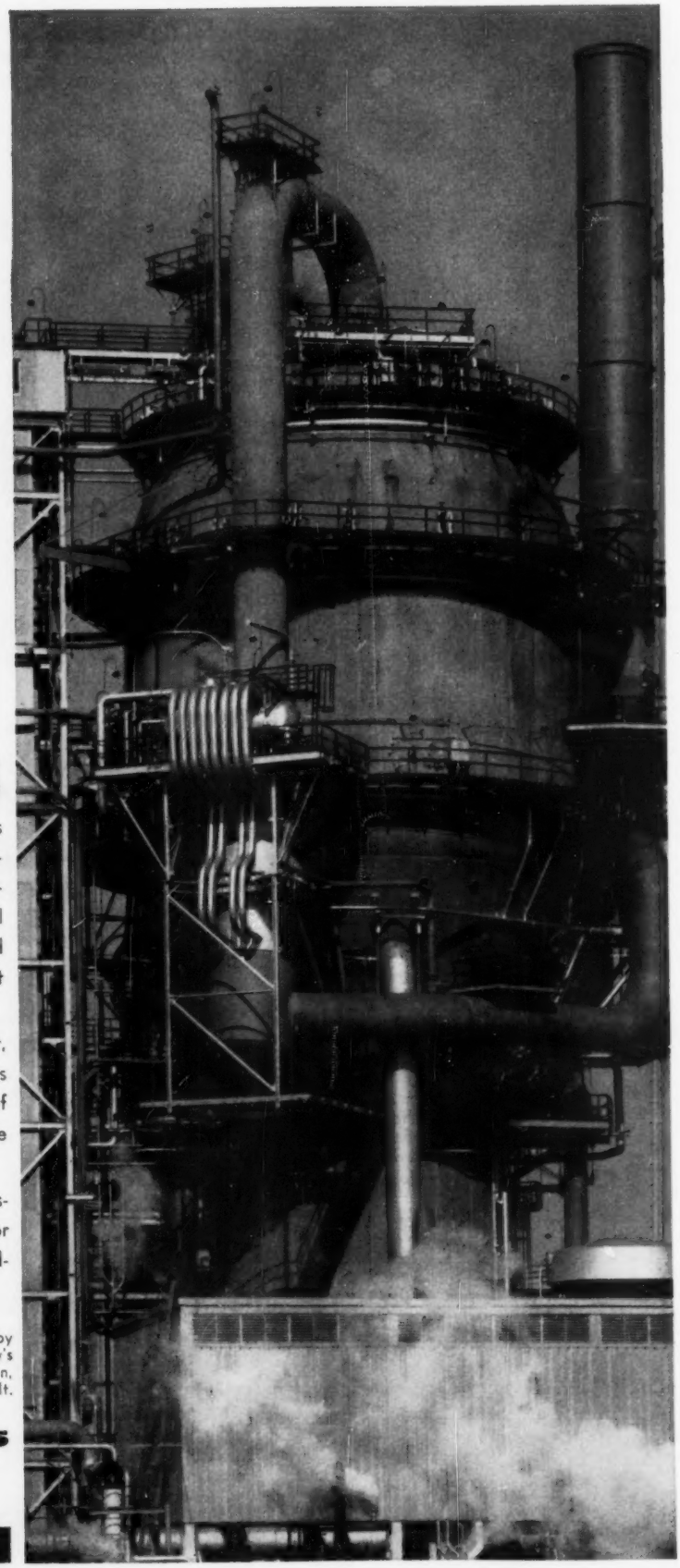
For more data on advertised products, use Readers' Service Cards, last page.

BUILT TO TOWERING PROPORTIONS BY NEWPORT NEWS

Newport News has all of the specialized skills and equipment needed to fabricate heavy process equipment used by the petrochemical industry. For example, Newport News can roll plate up to 5 inches in thickness and weld almost any type of metal, utilizing the most modern equipment and techniques.

To match its modern production equipment, Newport News has expert staffs of engineers and technicians backed up by thousands of skilled workmen who use these facilities with the highest degree of craftsmanship.

If you are considering the construction of pressure vessels, vacuum tanks, towers, reactors or related equipment, you'll find it to your advantage to get a bid from Newport News.



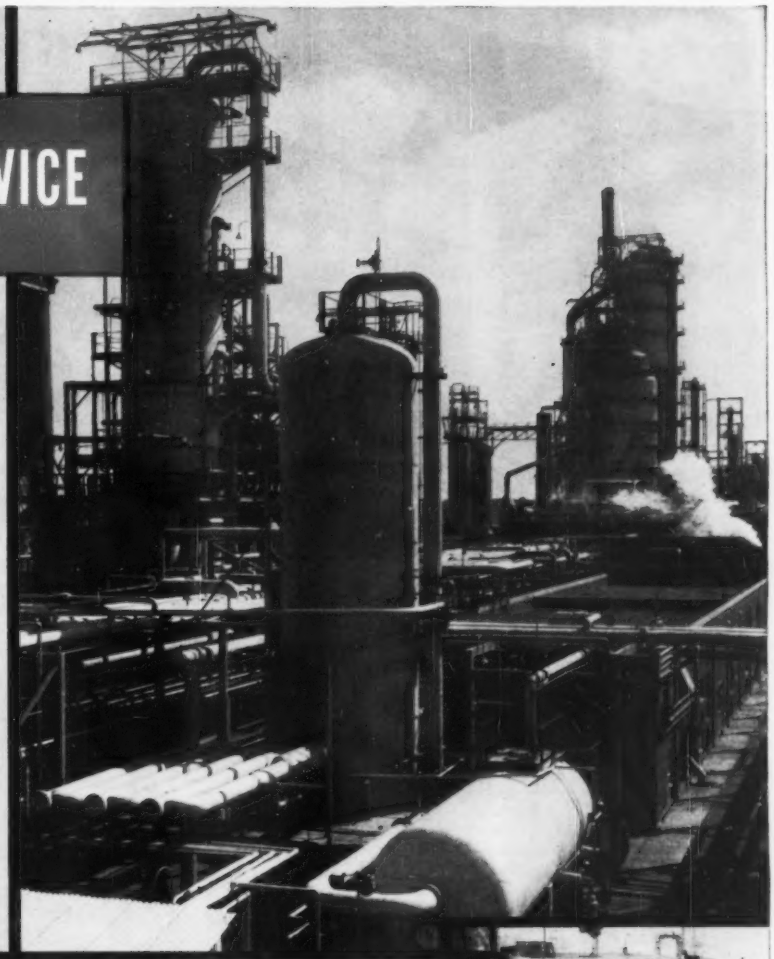
This 168' 9" Orthoflow converter, built by Newport News for Tidewater Oil Company's Delaware Refinery, south of Wilmington, Delaware, is the largest of its kind ever built.

Newport News
SHIPBUILDING AND DRY DOCK CO.
NEWPORT NEWS, VIRGINIA

another

TRETOLITE SERVICE report

KONTOL *Corrosion Inhibitor permits low pH operation in refinery's crude unit overhead system*



OHIO OIL COMPANY GETS EFFECTIVE CORROSION CONTROL, BETTER PRODUCT QUALITY AT REDUCED COST

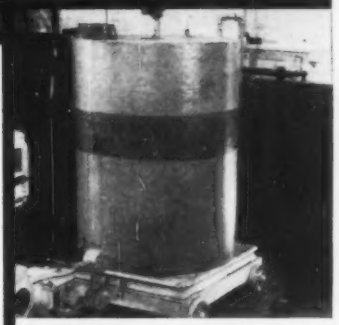
An outstanding performance record compiled over a five-year period in Ohio's refinery at Robinson, Illinois, proves the feasibility of low pH operation augmented by KONTOL* Corrosion Inhibitors.

Prior to inauguration of the low pH-KONTOL program, a high (7.5) pH operation on overhead receiver waters was fouling equipment. Heavy sludge deposits were accumulating ahead of exchanger baffles, and ammonia was contaminating hydrocarbon streams. These troubles limited the refinery to short runs at decreased capacity. *In addition, serious corrosion problems resulted in extensive equipment replacement and repairs after only nine months of operation.*

By changing to a low (4.0-4.5) pH and injecting KONTOL Corrosion Inhibitor at a rate of 10-15 ppm, Ohio has stopped sludging and greatly lowered ammonia contamination. Equipment has been kept clean, reducing maintenance costs and permitting longer runs at increased charge rates. Turnaround inspection has been lengthened to 18-month intervals. *No equipment failures due to corrosion occurred during this five-year period.*

Low pH operation supported by KONTOL corrosion control might offer important advantages for your refining facilities. Ask the Man in the Red Car to explain this program, or write . . .

*Registered trademark, Petrolite Corporation



Facilities such as this one for Kontol injection at various points are part of over-all corrosion control program at Ohio Oil Company's Robinson, Ill., refinery.

PETROLITE CORPORATION

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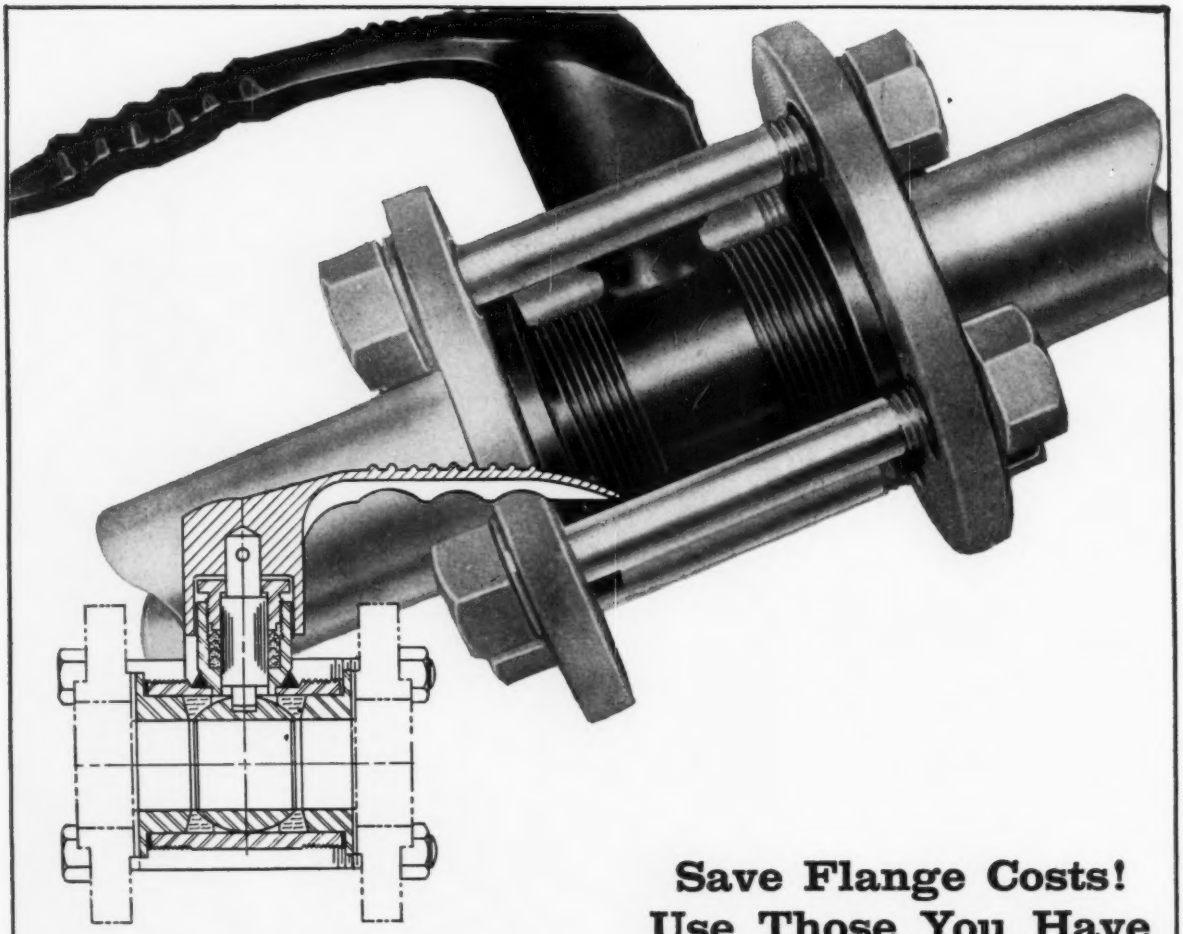
For more data on advertised products, use Readers' Service Cards, last page.



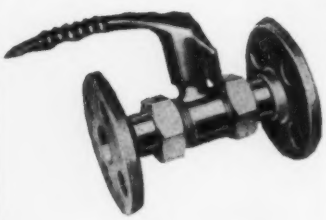
Save Flange Costs! Use Those You Have

Install Fullport Compression-Mounted Ball Valves in Seconds

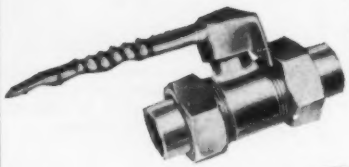
Fullport Compression-Mounted Ball Valves Model #8009 slip between the flanges of your present piping system with a minimum of down time. These valves which have the largest turbulence free port openings of any ball valves can handle corrosives and slurries with equal ease. The positive slotted key drive in the ball eliminates ball wear and ball wobble, permits equal flow in either direction. You get the best features of a globe, gate and plug valve in every Fullport Compression-Mounted Ball Valve —at one low price. The Teflon seats, the extra deep stuffing box and the exclusive "V" ring packing which eliminates troublesome "O" rings are Fullport extras for extra valve service and extra long life. The stem packing, if it should ever be required, can be replaced while the valve is in operation.

Fullport Compression-Mounted Ball Valves are immediately available in stainless steel in sizes ½" through 6". They test to 1000 psi cold non shock service and 300 psi at 400° F. Through bolts for compression mounting are supplied with each of these valves.

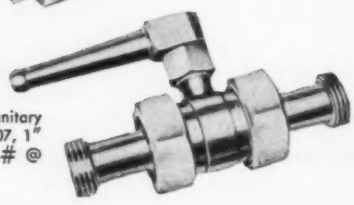
For more information about this and other Cooper Alloy corrosion resistant ball valves write for catalog #BVFA.



Fullport Stainless Steel Flanged Ball Valve, MSS and ASA face to face dimensions, #8002, ½" through 2", 150 PSI @ 400°F. service.



Fullport Stainless Steel Screwed Ends Ball Valve #8001, ½" through 2", 1000 PSI cold non shock 300 # @ 400°F. service.



Stainless Steel Sanitary Ball Valve #8207, 1" through 2", 150 # @ 400°F. service.

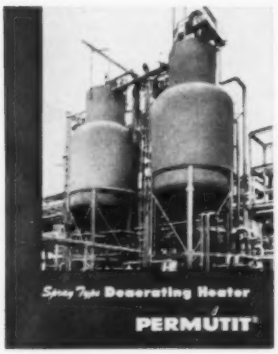
COOPER ALLOY

Corporation • Hillside, New Jersey

Build your FLUIDICS* library

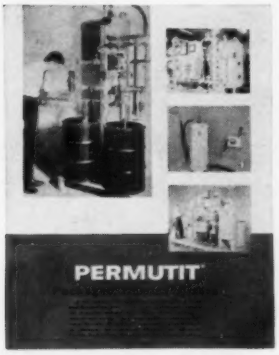
Automatic valveless gravity filter: Costs up to 45% less than conventional filters. Also saves money after installation, because it operates automatically without a single valve, agitator, pump, flow controller, or even an attendant operator. **Bulletin 4351.**

Permutit® Precipitator: Saves about 50% in ground space, 50%-75% in time of treatment, and 10%-40% in certain chemicals and adsorbents, compared to conventional reaction and settling tank. Complete facts on operation and application. **Bulletin 2204C.**

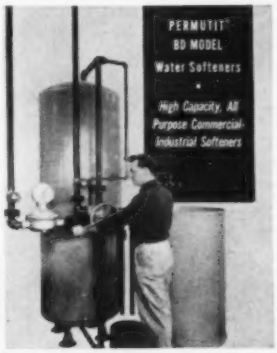


Deaerating Heaters: Designed for removal of carbon dioxide and oxygen from boiler feedwater. Permutit offers both Spray Deaerators, **Bulletin 2357** and Tray Deaerators, **Bulletin 4732.**

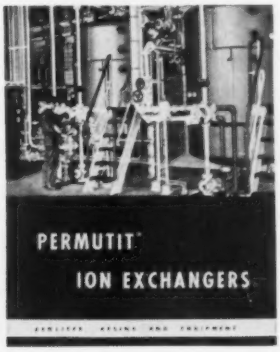
Water treatment chemicals: Permutit offers an extensive line of specialized chemicals. Typical data available: **Bulletin CS-105** on Wisprofloc-20 Coagulant Aid, **Bulletin CS-111** on Neutralizing Amines, **Bulletin CS-110** on the Permutit Briquet System.



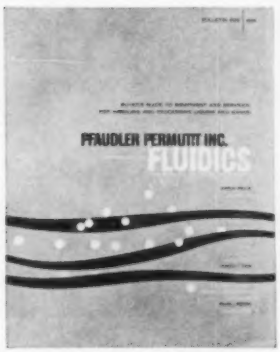
Standard packaged demineralizers: Factory-assembled, systems ready to connect and operate. For summary of applications, plus data on mixed-bed, two-step, non-regenerable and skid-mounted units, send for **Bulletin 4721.**



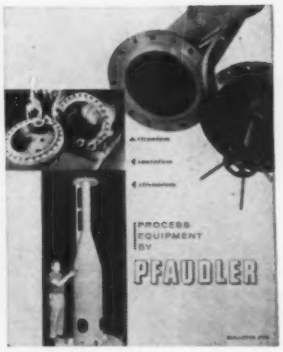
High-capacity water softening: New Permutit® Model BD Softeners answer need for more soft water at lower cost. Details on operation, specifications and performance are in **Bulletin 4696.** Industrial water softening with Permutit automatic equipment, Multiport Valve,® cation exchange, (zeolite) sodium cycle, systems and operation is described in **Bulletin 2386.**



Ion exchangers: From Permutit—the only company to manufacture ion exchange resins and the equipment in which they are used—you can get a brief manual on use of ion exchange as a unit process for purification, recovery, addition, separation, concentration. **Bulletin 2508** covers Permutit resins and equipment.



How FLUIDICS works for you: Buyer's Guide surveys equipment for water and waste treatment, ion exchange, gas analysis, metering and control. Also equipment for handling corrosives, heat transfer, reactions, centrifuging and packaging. Send for **Bulletin 992.**



"New" metals for processing: Tantalum, titanium and zirconium are finding increased use, because of their exceptional corrosion resistance and strength. Corrosion, heat transfer and general application data on these metals, plus equipment available, are discussed in **Bulletin 978.**

Treating industrial wastes: Bulletin 4486 discusses types of industrial waste problems, equipment used, typical waste treatment systems.

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

PFAUDLER PERMUTIT INC.

Permutit Div., Dept. PR-100 W. 44th Street, New York 36, N.Y.

Please send me the following bulletins:

- ☐ 4696 Permutit BD Model Softener
- ☐ 2386 Zeolite Water Softeners
- ☐ 4721 Permutit Packaged Demineralizers
- ☐ 4351 Permutit Automatic Valveless Gravity Filter
- ☐ 2508 Permutit Ion Exchangers
- ☐ 2204C Permutit® Precipitator
- ☐ CS-105 Permutit Wisprofloc-20 Coagulant Aid
- ☐ CS-111 Permutit Neutralizing Amines
- ☐ CS-110 Permutit Briquet System
- ☐ 978 Process Equipment by Pfaudler
- ☐ 992 FLUIDICS Buyer's Guide
- ☐ 4486 Equipment for Treating Industrial Wastes
- ☐ 2357 Permutit Spray Deaerators
- ☐ 4732 Permutit Tray Deaerators

Name..... Title.....

Company.....

Address.....

City..... Zone..... State.....

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accuracy

ASHCROFT DURAGAUGES measure pressure with precise accuracy no matter how severe the conditions of service

Ashcroft Duragauges are available in pressure ranges from 15 psi (or vacuum) minimum to 100,000 psi. Dial sizes: 4½" through 12".

sustained

The Bourdon tube in Ashcroft Duragauges is manufactured to precision standards of flexibility and mono-linked to the rotary movement. When pressure flexes the tube, the gauge pointer is always positively positioned, because it is mounted on the geared center shaft of the movement. Sustained high accuracy and long life are assured.

Choose your Ashcroft Duragauges made of components best suited to your needs. Eight Bourdon tube materials are available. Movement of stainless steel with nylon bearings and pinion gear for longest wear. Case materials: special aluminum alloy or tough phenol plastic.

The unique "Maxisafe®" Duragauge provides absolute protection to the viewer, plus easy and quick access to the mechanism. Your industrial supply distributor will help you select the best combination of components for your Ashcroft Gauge requirements. Phone him today or write for Catalog 300B.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

ASHCROFT PRESSURE GAUGES

A product of

MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

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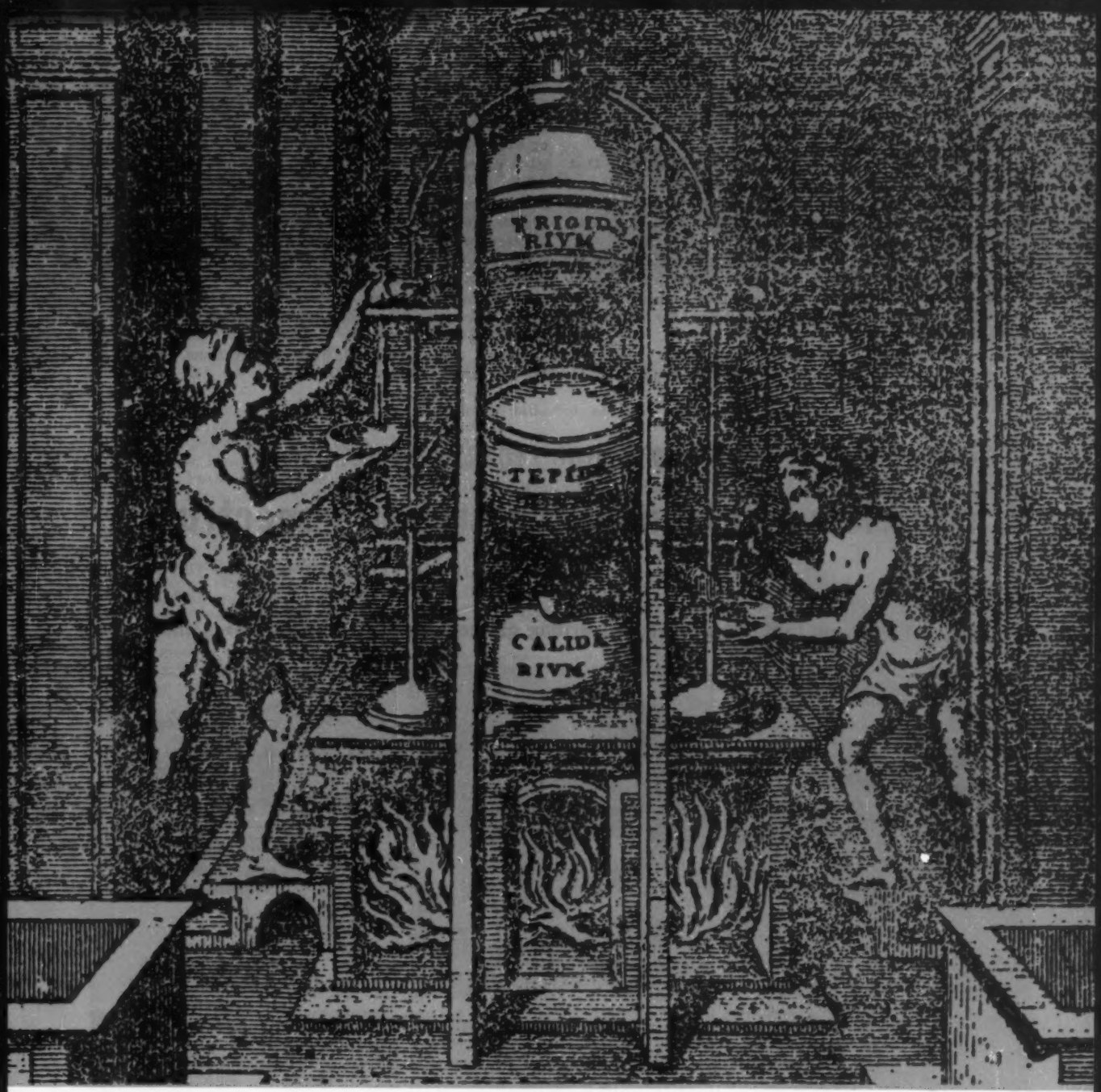


Where would we be without a still .....?

Without a still or two, many of us would find it dull, dry world. But vastly more important, without the huge, complicated stills that produce the myriad oil products essential for our modern life—for refineries are basically stills—it would be a different world indeed. For the past thirty years, the Japan Gasoline Company has designed and built some of the finest petroleum and petro-chemical plants in Japan. Be sure to consult our staff of experts in the field for all types of advice and assistance when building or enlarging your plant.

Engineers & Constructors

JAPAN GASOLINE CO., LTD.

New Otemachi Bldg., 2-4, Otemachi,
Chiyoda-ku, Tokyo, Japan.

There's a Bristol recording gauge to give optimum results on *any* pressure range—whether it's full vacuum, 10,000 pounds per square inch, or a few millimeters of mercury absolute.

And whatever type of element you select, you know that Bristol's continuing research and development program has kept it far in advance of the field . . . incorporating into it the latest improvements in instrument engineering and element metallurgy.

The product of over 70 years of instrument experience, Bristol gauges are *completely field proved*—some have been in service for over 40 years! An outstanding record! Among men who know recording gauges, it's Bristol for reliability, every time.

And check these big advantages:

Easy-change elements. Elements are designed for easy interchangeability. You can buy a gauge with any standard helical element; change later to a standard capsular element, or *vice versa*. Flexible polyethylene tubing for capsular element connections further simplifies change, speeds maintenance, and provides vibration isolation.

Extra mounting rigidity. Greater accuracy, greater reliability are assured by a rigid, cast-aluminum element mounting.

Element materials for every type of pressure measurement: Ni-Span C, 316 stainless steel, trumpet metal, phosphor bronze, and beryllium copper.

Get complete data on Bristol recording gauges, pressure elements, gauge charts and a variety of accessories in 32-page Bulletin G621 . . . yours for the asking. Write: The Bristol Company, 111 Bristol Road, Waterbury 20, Conn. o 1

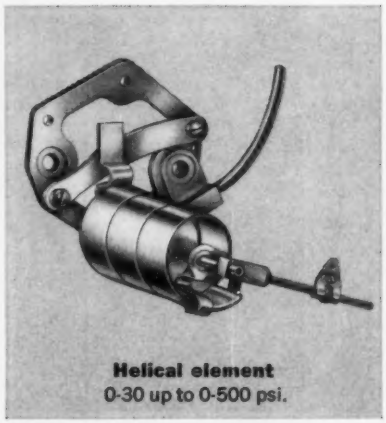
What are <u>your</u> recording gauge requirements?

Bristol elements blanket the pressure spectrum

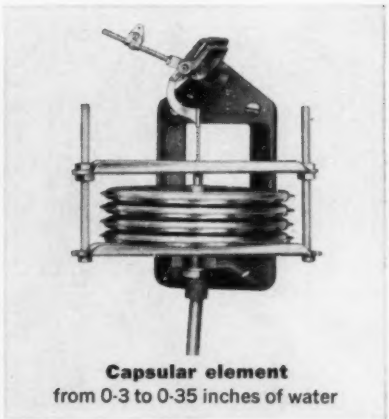
(0-6mm Hg Abs. to 0-10,000 psig)

. . . another big reason that more *Bristol* recording gauges are used than all others combined!

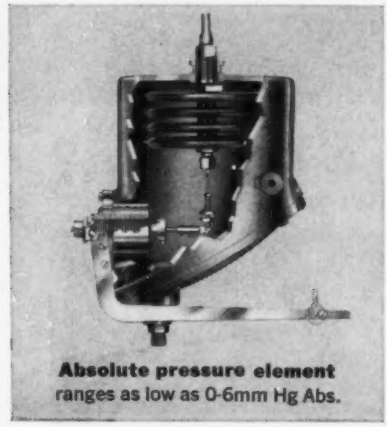
Helical element
0-500 up to 0-10,000 psi.



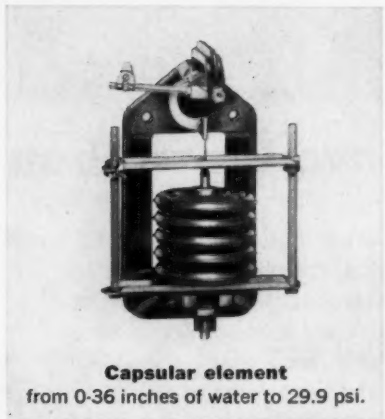
Helical element
0-30 up to 0-500 psi.



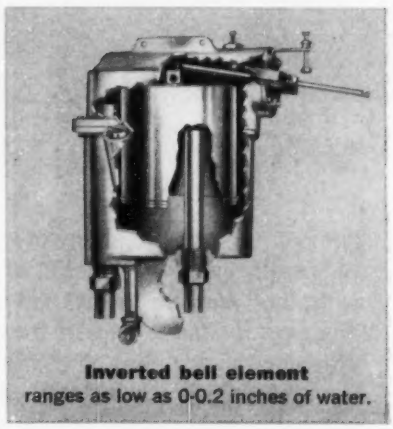
Capsular element
from 0-3 to 0-35 inches of water



Absolute pressure element
ranges as low as 0-6mm Hg Abs.



Capsular element
from 0-36 inches of water to 29.9 psi.



Inverted bell element
ranges as low as 0-0.2 inches of water.

BRISTOL . . . for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more data on advertised products, use Readers' Service Cards, last page.

New Otemachi Bldg., 2-1, Otemachi,
Chiyoda-ku, Tokyo, Japan.

NATIONAL AIROIL BURNER

ENGINEERING NEWS

NATIONAL AIROIL BURNER CO., INC. • 1284 E. Sedgley Ave. • Philadelphia 34, Pa.

You may wish to check certain items in this advertisement and forward to those concerned in your company.

ROUTE TO:

_____

_____

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National Airoil offers IMPROVED Model CP Vertical Firing Combustion Units

Here's big news! Now available is the *improved* National Airoil Model CP Vertical Oil Firing Combustion Units, ideally suited for use with stills, heaters, super-heaters, vaporizers, air-heaters, and other process furnaces in refineries, oil producing fields, and chemical plants. The units are used extensively in vertical and horizontal tube heaters of either cylindrical or box types. The units also are available for gas fuel and combination gas and oil.

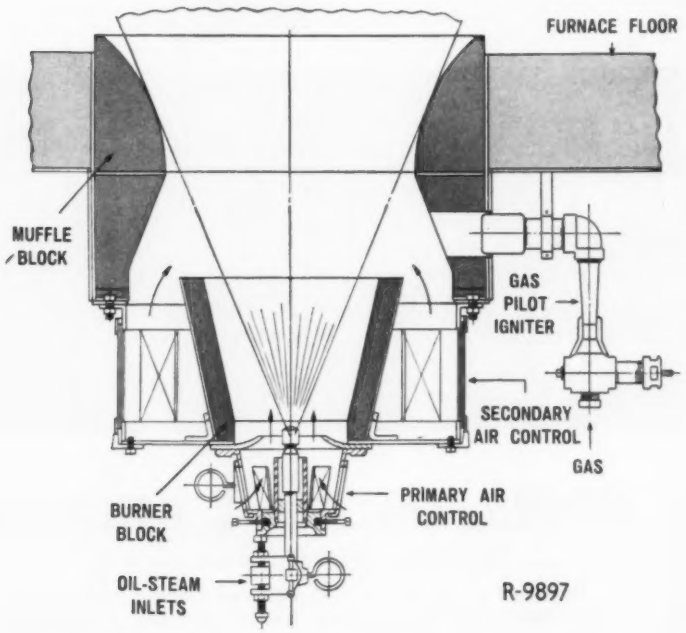
These modern CP oil units have added features that result in:

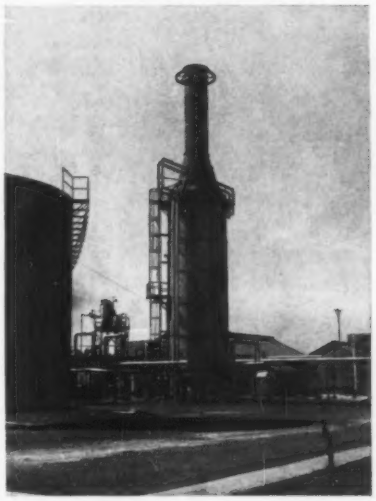
- **More stable fuel ignition.**
- **Higher economy of oil combustion with a minimum of excess air.**
- **Cleaner flames without dripping on heavy fuel oils.**
- **Flame patterns commensurate with furnace shape and arrangement of heat absorbing surfaces.**
- **Maximum radiation of heat from oil flame.**
- **Susceptibility to a varying demand of heat load.**

National Airoil CP oil units are available in six standard sizes that readily take care of the range of capacities most frequently specified. Two other special sizes are available for unusual conditions.

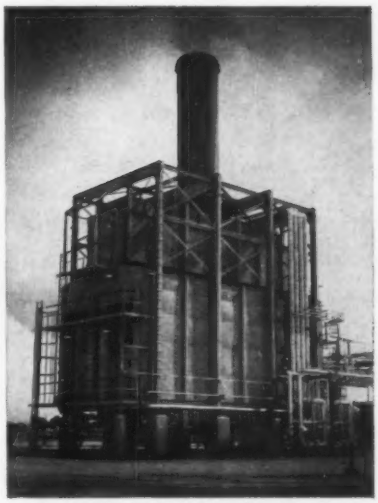
The units can be supplied to perform on natural or forced draft. On natural draft, they can be adapted to automatic combustion control, working the secondary air register. A different adjustment can regulate forced draft.

Where required, the CP units can be equipped with the dependable National Airoil Pilot-igniter Gas Burner for either continuous burning at 1% of the total heat load, or for intermittent operation as for ignition or start-up. Also, they can be furnished with the reliable National Airoil Electric Ignition System as used in chemical plants throughout the world.





Vertical cylindrical oil heaters perform more satisfactorily when operated with National Airoil CP Combustion Units.



National Airoil CP Combustion Units are ideal for use on horizontal tube, box furnaces like the one pictured here.

A National Airoil Representative will be happy to discuss how these improved CP combustion units will assure increased performance in your installation. Descriptive literature is available. Write today.

For more data on advertised products, use Readers' Service Cards, last page.

for this type service . . . specify this **STRONG** *trap:*

Dirty Lines or Dirty Steam:

Lowest Initial Cost per pound capacity:

Lowest Initial Cost per pound weight:

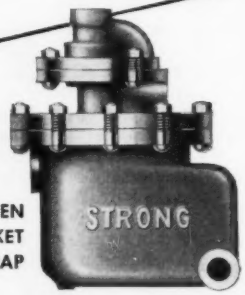
Eliminating Large Volumes of Air:

HYDRO-FLEX INVERTED BUCKET TRAP

FLOAT & THERMOSTATIC TRAP

Low Pressures with some air elimination:

Pulsating or Widely Varying Pressures:



OPEN BUCKET TRAP

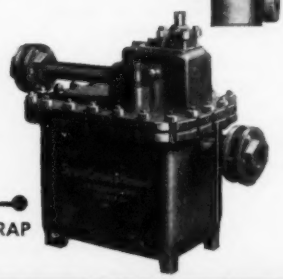
Continuous flow required:

BALL FLOAT TRAP

Draining a line carrying a vacuum discharging to atmosphere:

TYPE "A" VACUUM TRAP

Draining a line carrying a vacuum or very low pressure discharging against a hydrostatic head or back pressure:



TYPE "M" VACUUM TRAP

on every type service
STRONG steam traps give you longer life, less maintenance

Strong offers six types of steam traps to answer every requirement for removing condensate from all types of systems.

You can specify these Strong Traps with the assurance that you will get maximum service life. Proof is the fact that replacement parts are still being ordered for traps sold 50 years ago!

Here are some low maintenance features built into Strong Traps. Screwed-in, replaceable valves and seats of wear-resistant ANUM-METL. Deep-drawn, one-piece stainless steel buckets. Extra-heavy body and cover construction. Thorough testing. Interchangeable parts.

You will be money and years ahead when you specify Strong Traps. For further information, contact your local Strong distributor — he carries complete stocks and replacement parts, offers prompt service.

Selector Chart in Strong Catalog No. 69A gives trap recommendations for 45 types of equipment. Write for your copy or call your distributor.

4/S

STRONG, CARLISLE & HAMMOND

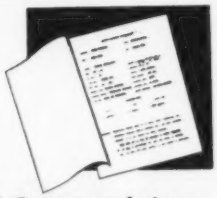
508 Sandusky Street • Conneaut, Ohio

steam traps • air traps • float traps • vacuum or pumping traps
F and T traps • continuous blowdown valves • separators • engine stops

For more data on advertised products, use Readers' Service Cards, last page.

How Oakite ECP engineered cleaning program speeds turnarounds, cuts maintenance costs

Oakite ECP stands for Engineered Cleaning Programs. It is chemical cleaning tailored individually for specific refineries to give the shortest turnaround time consistent with good results. Each ECP takes into account a refinery's particular conditions, equipment, through-put. It itemizes the problems involved, and suggests methods and materials to solve those problems. In putting the chemistry of cleaning to work, it utilizes the experience of Oakite engineers, the latest research results and the skills of laboratory and field technicians.



Specific Recommendations

The Oakite ECP makes specific cleaning recommendations, valve by valve, tower by tower. It includes estimates of material quantities needed and off-stream time expected for specific items of processing equipment and specific areas of general refinery maintenance.

Process Equipment Cleaning

- Bubble cap, cascade and perforated tray type towers
- Raschig ring towers
- Heat exchangers
- Condensers
- Reboilers
- Preheaters

General Refinery Maintenance

- Storage tank cleaning
- Tank car and truck cleaning
- Reclamation of valves, fittings, pipe
- Drum washing
- General Cleaning of Equipment and work areas for safety and appearance

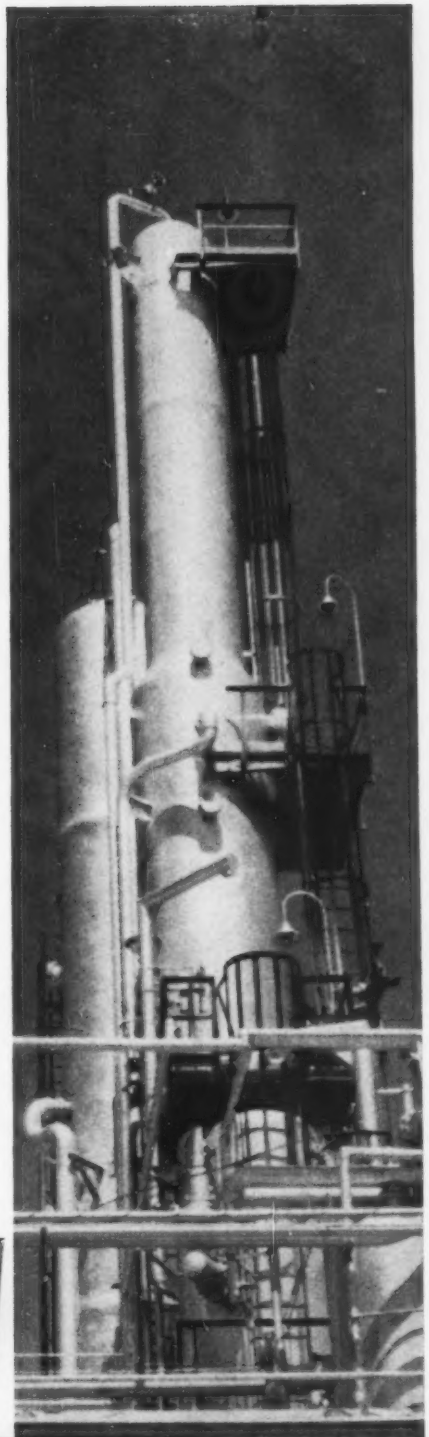
Research Laboratory Service

The world's finest laboratory facilities engaged in cleaning research are offered to analyze stubborn soils, recommend suitable cleaners, and implement the Oakite petroleum engineers' knowledge in all phases of refinery cleaning.

Detailed Engineering Assistance

A fully staffed engineering department develops standard mechanized cleaning units with a wide variety of refinery uses. Among these important developments are The "Hurriclean" Steam-Detergent Gun for removing caked-on soils from salvage parts too large for tank immersion. The Interior Tank Cleaning Unit to expedite change-over in cars and barges. The portable Hot-Spray Unit for general maintenance cleaning in and around pump houses.

FREE BOOKLETS *give details of Oakite Engineered Cleaning Programs. Write Oakite Products, Inc., 50B Rector Street, New York 6, N. Y. Better yet, ask your local Oakite man to develop an ECP for your refinery. There's no obligation, of course.*



OAKITE

50 years' leadership in industrial cleaning

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

Oakite ECP

your economy key

Jefferson Gas Processing Specialist helps pick the right chemicals

You may be in the initial planning stages of gas processing facilities. Or, you may be altering an existing dehydration or gas sweetening unit. In either event, selection of the right chemicals is most important. Here, Jefferson's Gas Processing Specialist can help.

He will thoroughly review your proposed processes and expected operating conditions with your engineers. In the removal of water by either glycol absorption or injection, the type unit, nature of the gas stream, degree of dew point depression and hydrate inhibition as well as the properties of the glycols are important in determining the *right* glycol . . . ethylene, diethylene and triethylene glycols or HI-DRY® tetraethylene glycol. Similarly in gas sweetening, the type and composition of the gas stream to be treated and final purity of product are important factors in the proper choice between monoethanolamine and diethanolamine sweetening.

Jefferson's Gas Processing Specialist can also suggest the most economical handling and storage practices for your operation, the best shipping means, and, of course, supply all your glycols and amines in the quantity and purity you need . . . Jefferson Chemical Company, Inc., 1121 Walker Avenue, P. O. Box 303, Houston 1, Texas.

Ethylene and Propylene Oxides, Glycols, Dichlorides, Carbonates
SURFONIC® Surface-Active Agents • Ethanolamines • Morpholine
N-Alkyl Morpholines • Polyethylene and Polypropylene Glycols
Piperazine • Piperazine Salts • Nonyl Phenol • Caustic Soda

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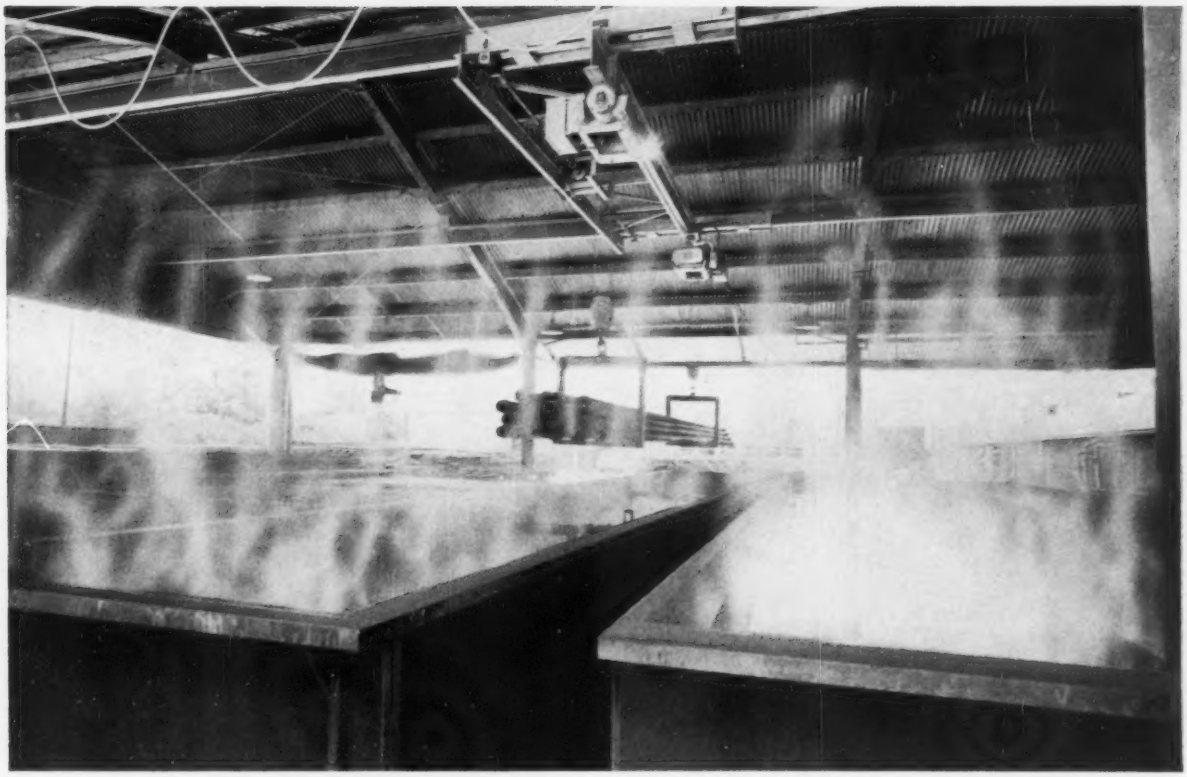
JEFFERSON CHEMICALS

061



AFTER 18 MONTHS
NO corrosion damage with Napko COAL TAR EPOXY

The roof and steel beams of this pickling tank shed show no trace of corrosion damage after being subjected to 18 months of constant exposure to sulphuric acid vapor and steam from hot caustic solutions. The reason: Napko's advanced COAL TAR EPOXY!

Laboratory and field tests have proved that C. T. E. gives you the greatest possible resistance to corrosion by salt water, mineral acids, alkalis, petroleum products and abrasion damage.

The exclusive Easy-Flow formula of Napko C. T. E. permits applications up to 20 mils thick without runs or sags — without expert application techniques. You save labor time and money with faster application, fewer costs. This extra heavy film bridges small crevices and rough edges, the areas where thinner films tend to fail, and gives your equipment complete pin-hole free protection.

Find out how Napko Coal Tar Epoxy can help you solve your corrosion problems. Write for more information and complete specifications *today!*

PROJECT SERVICES OF NAPKO CORPORATION

1. Climatic-Operational Analysis
2. Lab Testing & System Research
3. Field Testing
4. Paint Crew Training
5. Job Inspection in Progress
6. Case History for Repaint

Complete Coating Systems for every Industrial Requirement

NAPKO CORPORATION

INDUSTRIAL COATINGS DIVISION

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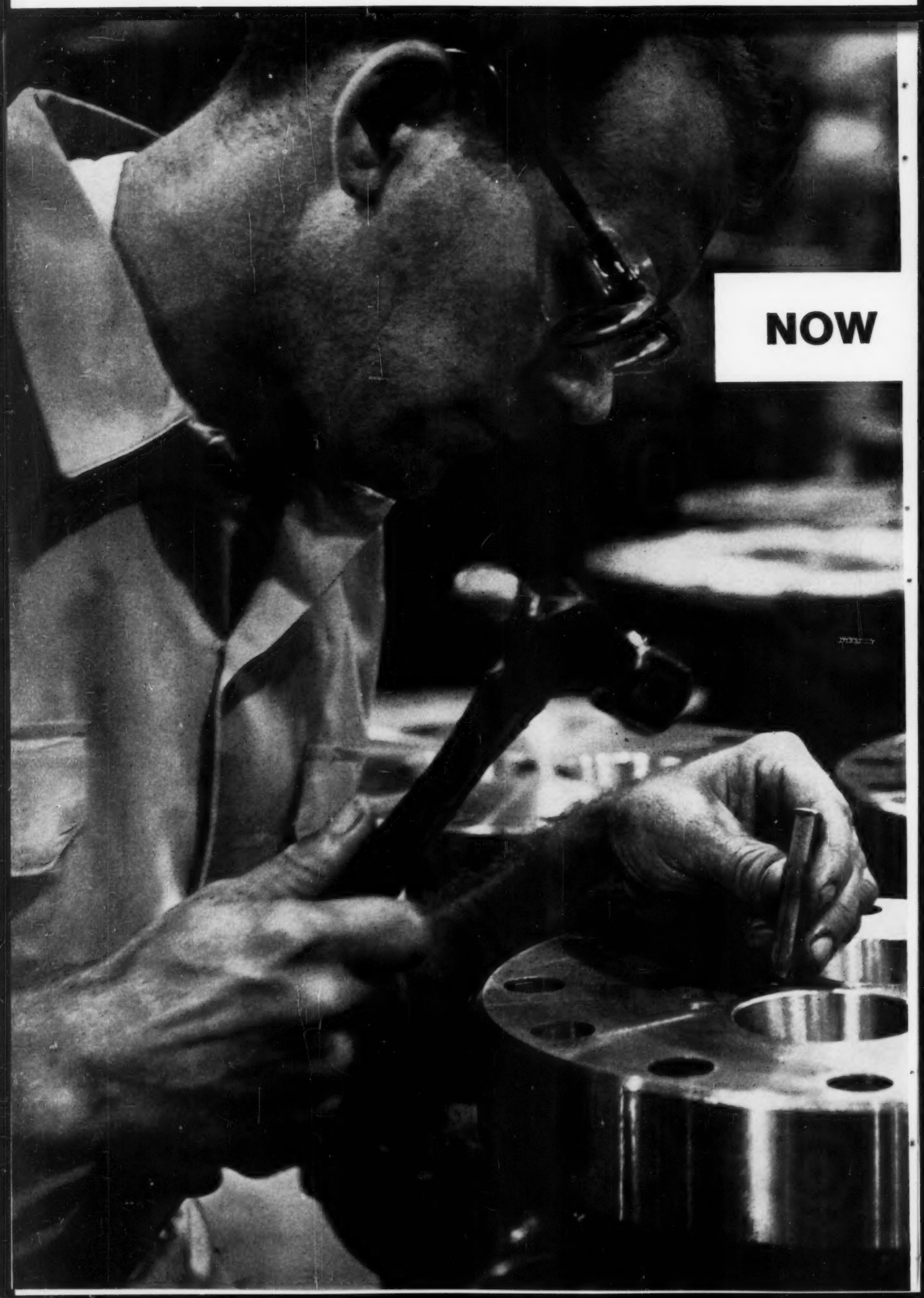
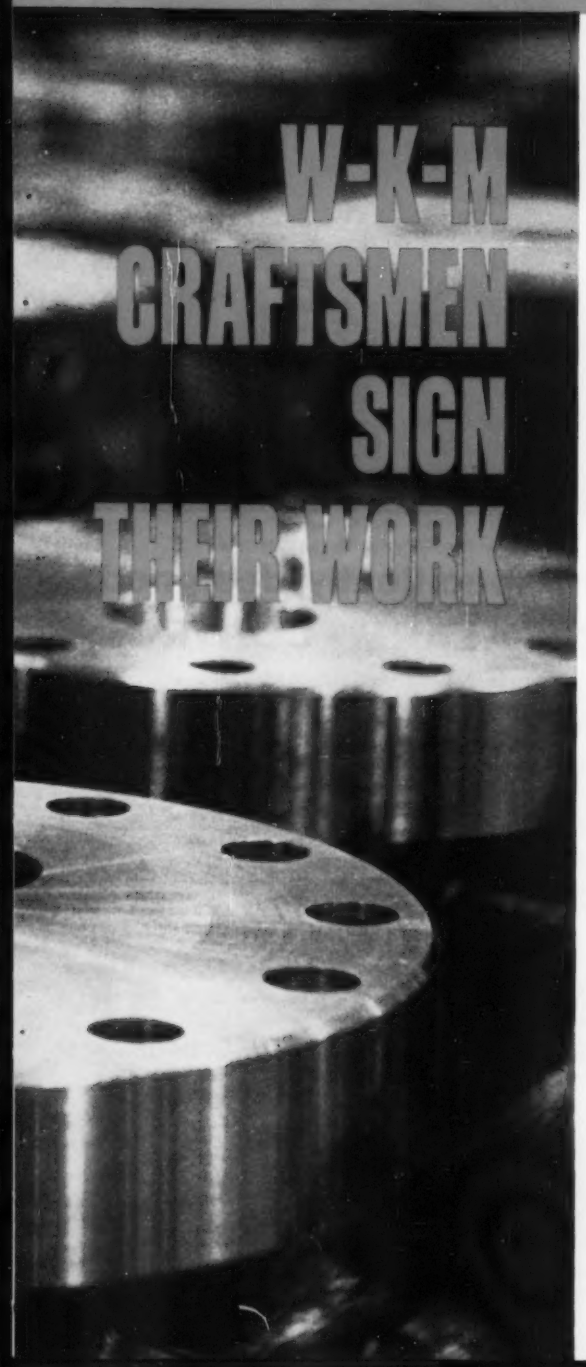
For more data on advertised products, use Readers' Service Cards, last page.


NOW

TOTAL Valve Engineering



4 / 41 / 89 / 16 / 12 / 2 / 17
98 / 13 / 65

What these "Hallmarks of Quality" on the parts of every W-K-M Valve mean

Examine any important part and you'll find stamped in the metal the *personal* seal of each W-K-M craftsman who worked on it.

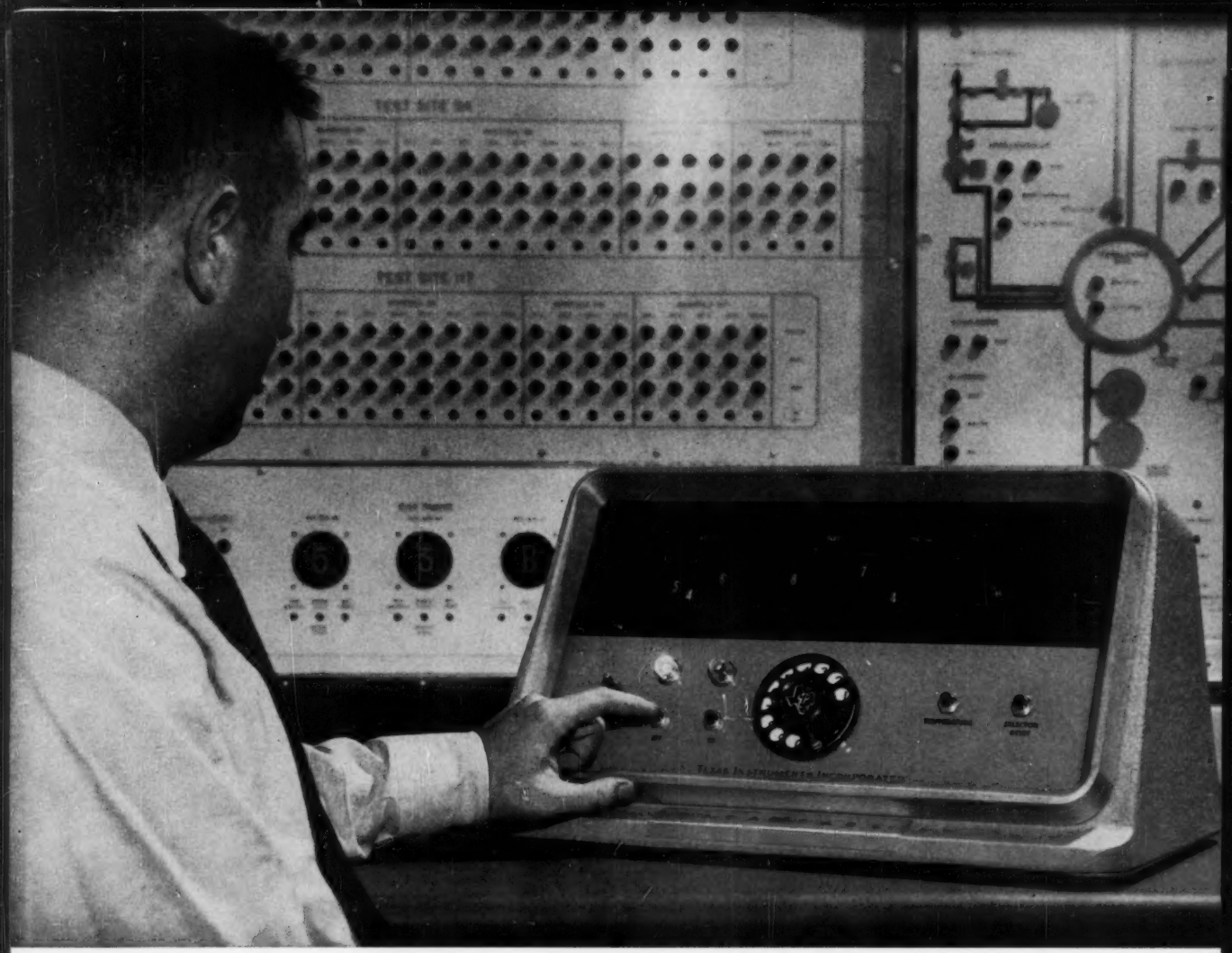
These marks denote a pride of workmanship that gives you greater assurance of trouble free service. For quality must be built into a valve on the *production line* as well as on the drawing board.

To achieve the unique personal responsibility of every man, at W-K-M takes *human* engineering. It is a vital part of TOTAL Valve Engineering—W-K-M's unique dedication to *all* phases of valve technology. Another reason why W-K-M Valves work better, last longer . . . on the world's toughest jobs.

W-K-M

DIVISION OF ACF INDUSTRIES
INCORPORATED
P. O. BOX 2117, HOUSTON, TEXAS

6004



Use the only tank gauge system specifically designed for COMPLETE MEASUREMENT-ALARM-CONTROL

DATA-GAGE* system is the only field-proved tank gauge system that provides the multi-purpose functions of measurement, alarm and control without extra, expensive control and selector equipment. And, it is the only system that performs all these functions with the high degree of accuracy and reliability you require . . . check these outstanding features carefully:

Accuracy — DATA-GAGE system measures surface level to 1/16-inch accuracy in either stationary or floating roof tanks . . . is accepted for auditing purposes by major oil companies.

Reliability — DATA-GAGE *system cannot give false information!* All binary decimal code transmissions are automatically triple-checked before data is displayed. Float must break from the fluid surface to provide readout; point connections are verified from the field; polar code eliminates possible long-short ambiguity.

Versatility — *Same equipment* provides: digital and analog measurement including accumulator readout; control for motors, pumps, pilot valves, two- and three-position valves, adjustable chokes, controller set-points, etc.; alarm indication from any sensing contact. DATA-GAGE system can be provided with automatic programmers, data loggers, alarm and status displays.

Capacity — Up to 1000 tanks can be measured for liquid level and temperature with one standard system.

Economy — DATA-GAGE system has both low initial and long-range cost. No expensive extras are required. Code lines and power lines can be run in same conduit . . . often existing ground level gauge connections and pipes can be utilized. Transistors are used instead of short-lived vacuum tubes. Easy access plug-in units make this the easiest and safest to service of all systems.

For more detailed information on the DATA-GAGE system, request Bulletin No. M-601. If you have any problems in remote measurement and supervisory control, TI application engineers can help you.

TEXAS INSTRUMENTS
INCORPORATED
GEOSCIENCES & INSTRUMENTATION DIVISION
3609 BUFFALO SPEEDWAY • HOUSTON 6, TEXAS • CABLE: TEXINS

*DATA-GAGE is a trademark of Texas Instruments. The system is licensed under Sun Oil Company patents.

Is Your Plant Getting Half Value Out Of Your Heat Exchanger Dollar?

It Is If You Consider Only the Initial Cost

As a major component in processing operation, heat exchangers deserve critical study beyond their initial price. Every processor should carefully analyze their in-plant cost. Here is where standardized, modular Brown Fintube double pipe heat exchangers really offer significant operational savings.

1. **LOWER INSTALLATION COSTS:** Using one standard B.F.T. unit reduces installation costs up to 30%.
2. **COMPLETELY SALVAGABLE:** When duties change, B.F.T. sections are added or stored, never scrapped.
3. **EASIER MAINTENANCE:** Only one type of unit to service.
4. **LOW PARTS COSTS:** Just four standard inexpensive replacement parts with a B.F.T. equipped plant.
5. **NO DOWNTIME:** Valving parallel streams permits double pipe units to be serviced during operation.
6. **STANDBYS READILY AVAILABLE:** Standardization permits a standby to be stocked, if desired.
7. **IMMEDIATE DELIVERY:** From the United States, Canada, England, France, Germany, Japan, and Mexico.

LOW PRESSURE HEAT EXCHANGERS

Bulletin 110 describes Brown's revolutionary new heat exchangers with improved maintenance features. For your complimentary copy write Brown Fintube Company, 300 Huron Street, Dept. P10, Elyria, Ohio, 'phone FAirfax 3-3291.

HEAT EXCHANGE SURFACE
BROWN FINTUBE
HEAT TRANSFER PRODUCTS

BROWN FINTUBE

SYMBOL OF EFFICIENCY IN HEAT TRANSFER PRODUCTS

NEW Philadelphia Side-Entering Mixers are More Compact, More Powerful...*Yet Cost Less*

Before you buy, be sure you get all the facts on the new Philadelphia side-entering mixer. This compact design has a generous reserve of gear capacity, rugged shafting, and large bearings — all features that minimize maintenance costs. And what about purchase cost? It is less than that of *any mixer* of comparable quality.

Interested? Then check these outstanding advantages.

1. Its compact design minimizes the need for turnbuckle supports or other mixer bracing from the tank wall.

2. You'll get greatly increased gear life because the spiral bevel gear drive has over twice AGMA required capacity for use with maximum standard motor sizes.

3. Your maintenance costs will be less because the one piece reducer and reducer support stand housing is rugged and rigid. Gearing and shafting run truer. Run-out at the shaft seal is minimized.

4. One man can change the mechanical seal or repack the stuffing box quickly and easily when this is occasionally necessary. With all standard units this can be done with a full head of liquid in the tank.

But this is only part of the story. For more complete information write for our new Catalog PSE-60.

philadelphia mixers

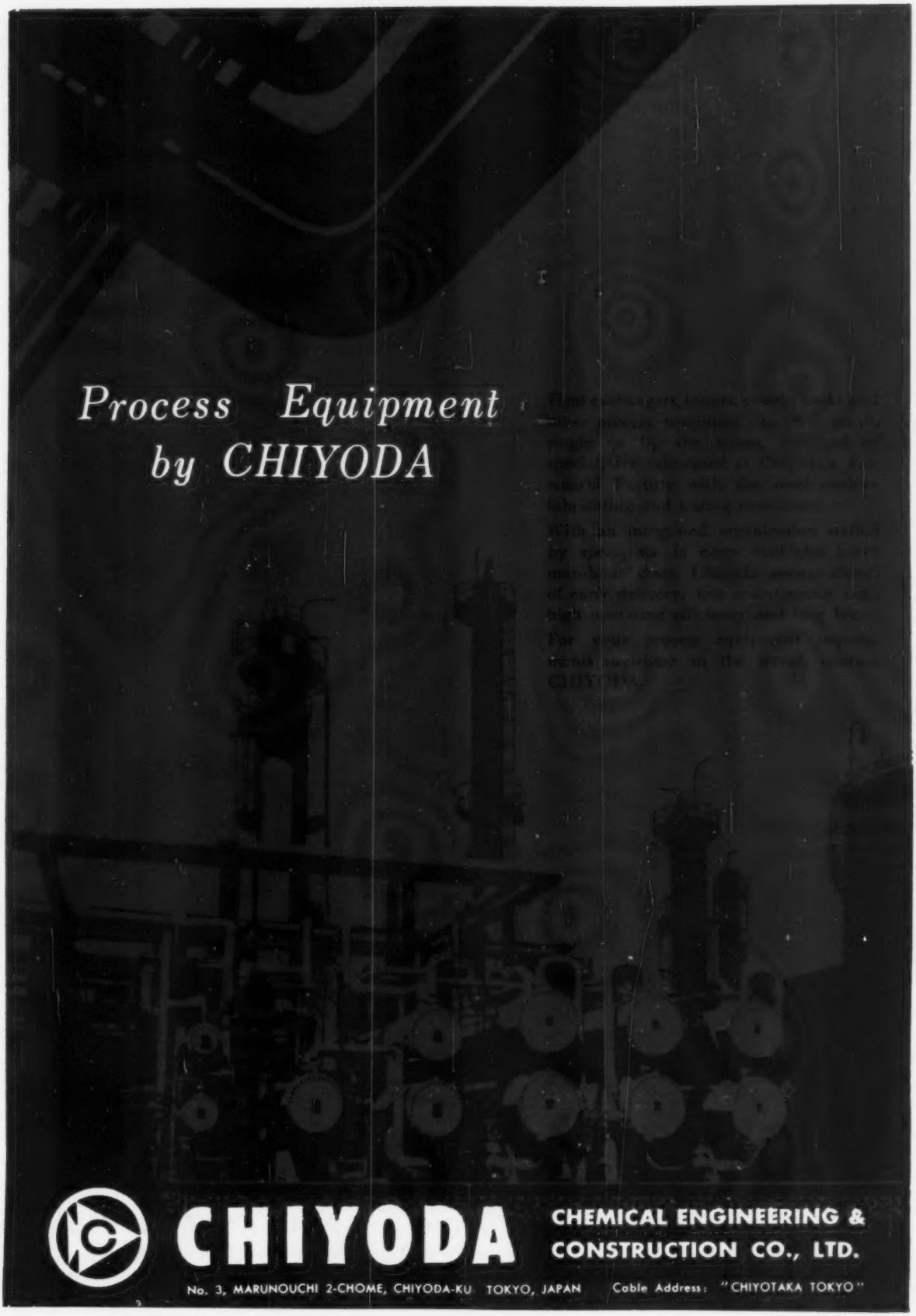
PHILADELPHIA GEAR CORPORATION

King of Prussia (Suburban Philadelphia), Pennsylvania

Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

For more data on advertised products, use Readers' Service Cards, last page.


Process Equipment
by CHIYODA
CHIYODA
CHEMICAL ENGINEERING &
CONSTRUCTION CO., LTD.
No. 3, MARUNOUCHI 2-CHOME, CHIYODA-KU TOKYO, JAPAN
Cable Address: "CHIYOTAKA TOKYO"

On the fireboat *"City of Portland"*, a Rockwood FOAM system with variable automatic proportioning of the fire smothering foam liquid includes Rockwood turret nozzle convertors, hose nozzles, applicators and extensions. Pumping power supplies a continuous output of 7,000 gpm. Smaller photo shows refueling on this boat with Double Strength FOAM liquid through a trough-like funnel into a 250 gallon FOAM storage tank.

Rockwood helps protect Portland

Fireboat's FOAM system provides 3600 cubic feet of fire-smothering blanket — in 3 minutes!

For up-to-the-minute protection of the harbor area of Maine's metropolis, the fireboat "*City of Portland*" carries a Rockwood FOAM system engineered for fast, effective fire fighting.

This Rockwood balanced pressure proportioning system incorporates all latest mechanical developments, including automatic control of FOAM liquid injection, variable percentage selection, individual selection of FOAM or water discharge and use of nozzles that can discharge FOAM, FogFOAM, WaterFOG or straight water streams.

The FOAM metering valves can be set for Double Strength (3%) or Regular Strength FOAM Liquid (6%). System will maintain the desired percentage automatically, regardless of pressure or flow variations. FOAM tank can be quickly refilled for maximum discharge of 82,000 gallons of expanded FOAM per tankful.

Protective advantages like these are typical of Rockwood systems and products for fire fighting vessels, vehicles or industrial hazards. Tested and Listed By Underwriters' Laboratories, Inc. For details, write to ROCKWOOD SPRINKLER DIVISION, 504 Harlow Street, Worcester 5, Massachusetts.

ROCKWOOD SPRINKLER DIVISION

of The Gamewell Company • Subsidiary of E. W. Bliss Company

Engineers Water...to Cut Fire Losses

Distributors in all principal cities

Transformer oils get a new lease on life with DBPC® antioxidant

Transformer insulating oils inhibited with DBPC® antioxidant assure utility companies of longer, more effective protection of transformer parts. DBPC antioxidant inhibits the oil against oxidation, prolonging its useful life by preventing the formation of sludge deposits. Years of performance show that new transformer oils treated with DBPC antioxidant serve 14 times as long at a cost of only 1½¢ more per gallon. The result is superior protection of transformer insulation and reduced costs for maintenance and oil changes.

DBPC is not only low in cost, but it produces no detrimental side effects. It is easily and safely handled and requires only dissolving in the transformer oil. Its basic stability and long-range protection have served most of the oil refiners.

Koppers DBPC is also used by refiners in stabilizing other petroleum products such as gasoline, plastics, waxes, industrial fats, greases and industrial oils. For more information on using DBPC for your needs, write: Koppers Company, Inc., Tar Products Division, Pittsburgh 19, Pa.

KOPPERS

KOPPERS

Koppers Company, Inc.

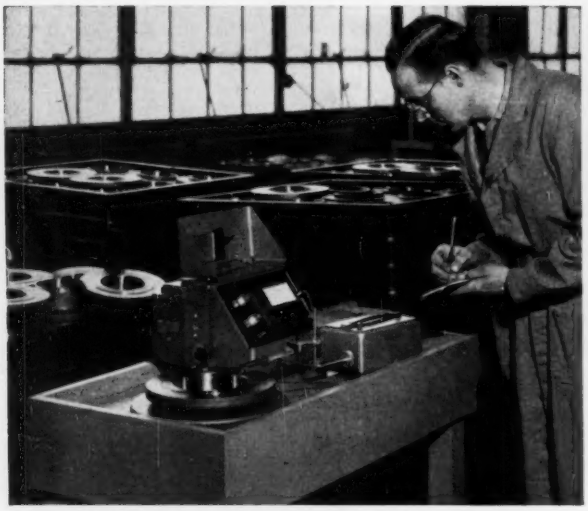
Offices in Principal Cities

In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ont.

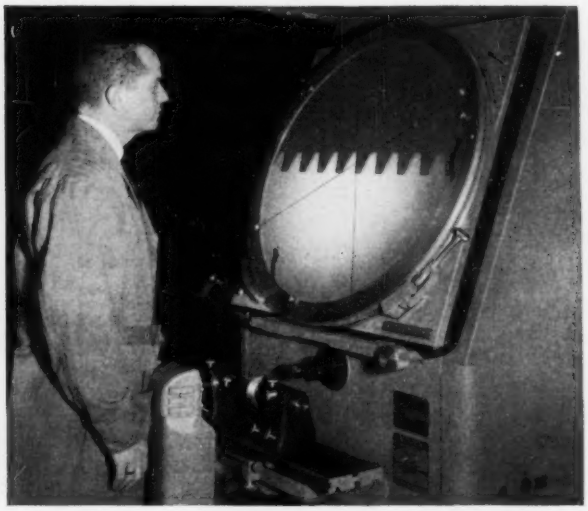
. . . IN THE HANDS OF DEDICATED MEN . . .

The know-how and dedication of the men who use the precision testing equipment shown here for proving every operation in the manufacture of VOGT products is an important factor to the companies who have come to rely on the Engineered Excellence of the VOGT Equipment they buy. As an example, the constantly improved forging, finishing and inspection techniques employed in the manufacture of VOGT forged steel valves, fittings and flanges, have kept them in the forefront for safe and reliable handling of liquids and gases over a wide range of pressures and temperatures found in petroleum refineries, chemical, petro chemical and power plants.

At VOGT no manufacturing procedure is left to chance. All standard measuring instruments such as scales, verniers, calipers, micrometers, indicators, plug gates, etc. are employed with other special precision measuring instruments as shown in these pictures.



This Surfindicator electronically measures surface roughness in micro-inches. Used for "on-the-spot" testing of the surfaces of gaskets, stems, gates, seats, bonnets, etc.



This 30" Optical Comparator reveals contour uniformity and angularity of form tools and provides an elaborate inspection facility for checking formed parts for close tolerances.

A PICTURE STORY OF Quality

HENRY VOGT MACHINE CO.
LOUISVILLE 10, KENTUCKY

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For Direct Long Distance to Louisville
Dial: 502 Me 4-9411

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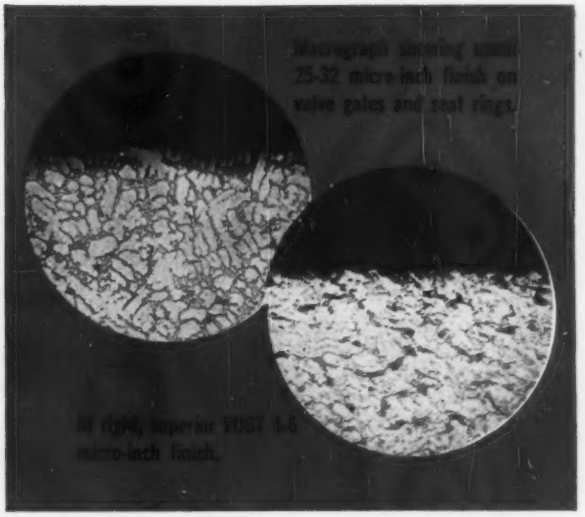
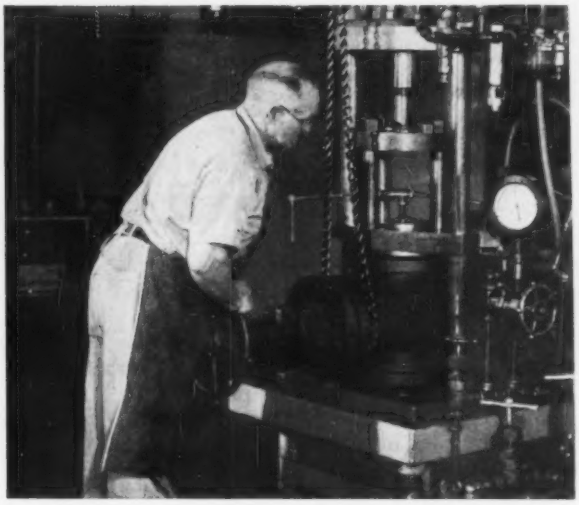
The Balphot Research Metallograph is used for routine and research metallographic examination of the structure of materials.



Special lapping machines provide a 4-6 micro-inch finish on VOGT valve seat rings and gates for positive closure.

Optical flats, used in conjunction with monochromatic light, measure flatness and surface finish of valve gates and seat rings in terms of light bands. Flatness is held to 2 light bands or 0.000022".



Fitness to perform beyond the specified work load for which any VOGT valve is made, is proved by this final hydraulic pressure test with oil, which follows a pneumatic body and seat test with air under water.

Control

in the manufacture of Vogt Forged Steel Valves, Fittings, Flanges and Unions

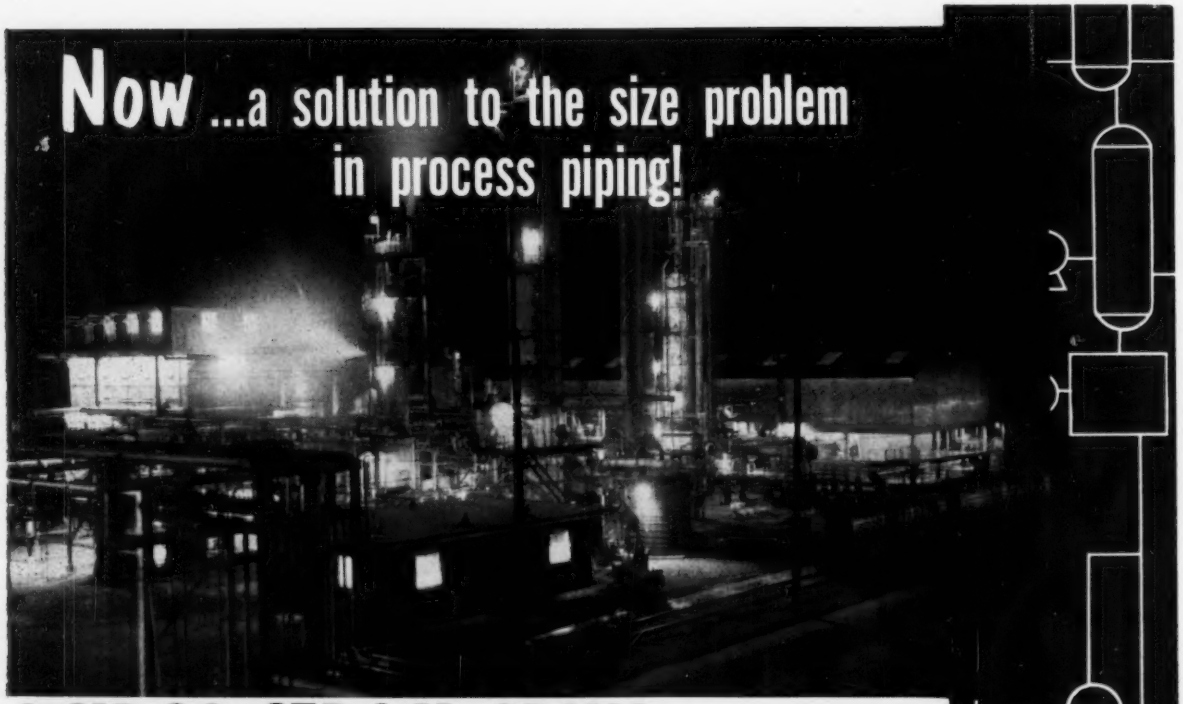
ENGINEERED

by Vogt

EXCELLENCE

For more data on advertised products, use Readers' Service Cards, last page.

Now ...a solution to the size problem in process piping!



ACIPCO CERAM-SPUN STEEL TUBING

...offers a wider range of O.D.'s from 2.25" to 50"; wall thicknesses from .25" to 8"; lengths up to 20'.

Prompt procurement of tubular process piping for the refinery and petro-chemical industries has become a concern to design engineers as specified sizes have steadily progressed to larger diameters and heavier walls.

Now, size can be less of a problem . . . thanks to new ACIPCO CERAM-SPUN tubing. This revolutionary process has resulted in the availability of centrifugally spun process piping in practically every conceivable variation of diameter and thickness . . . and without costly tooling charges. Here is greater freedom in design . . . and increased savings.

Retorts, reformer and furnace tubes, heat exchangers, as well as many other pieces of equipment, have been fabricated from ACIPCO centrifugally spun tubing.

Investigate the advantages of ACIPCO CERAM-SPUN tubing. ACIPCO's complete facilities offer service from centrifugal or static castings to finished parts.

ASA Code for Pressure Piping — Petroleum Refinery Piping (ASA B 31.3-1959) authorizes the use of centrifugally spun stainless pipe made in compliance with ASTM Specification A426-58T. This specification is entitled, "Centrifugally Cast Ferritic Alloy Steel Pipe for High Temperature Service." Write for a free copy.

SIZE RANGES: Tubes are produced in lengths from 4' to 20'; longer lengths are made by welding. O.D.'s from 2.25" to 50" — wall thicknesses from .25" to 8".

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steels, plain carbon steel and special non-standard analyses.

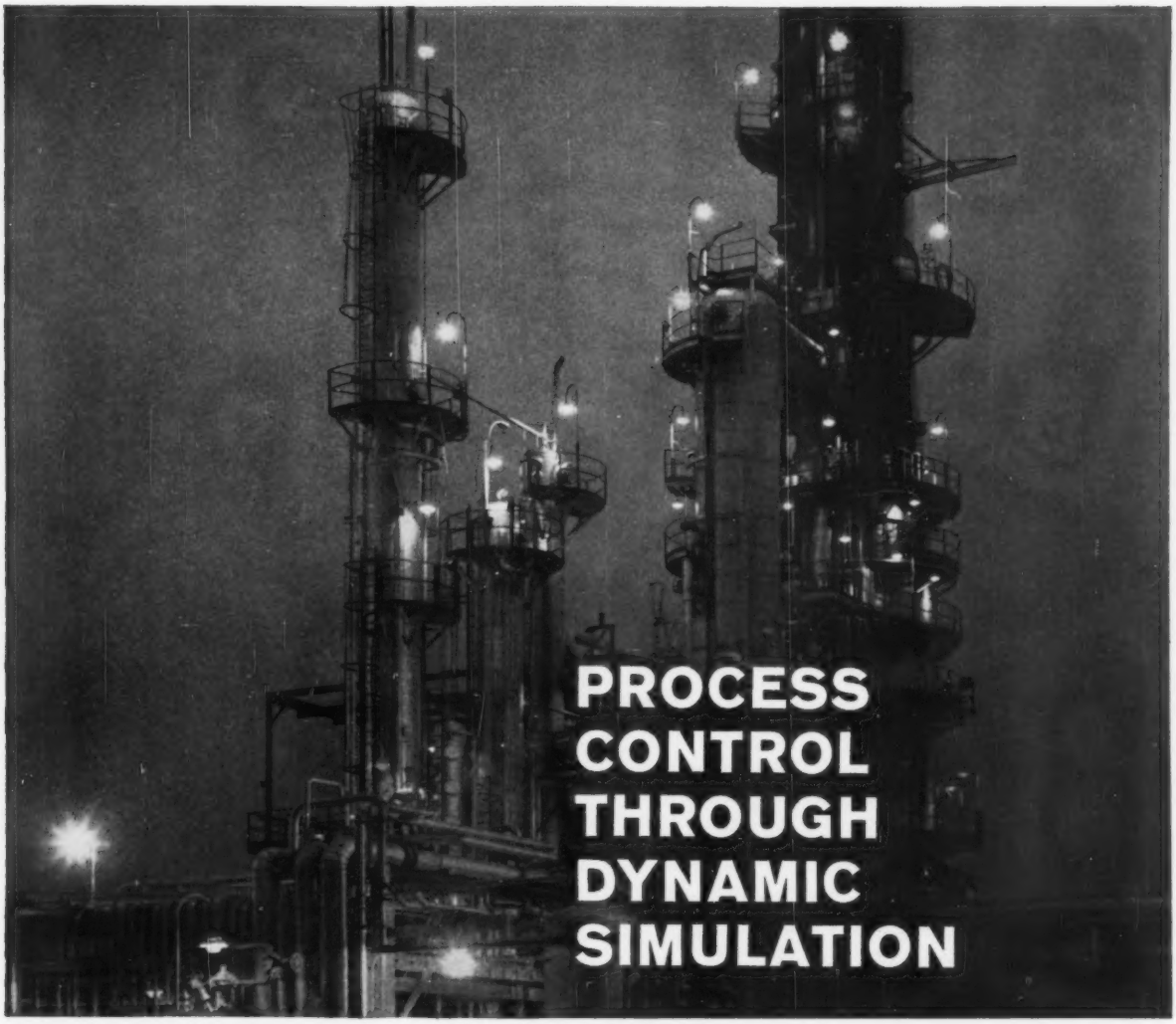
FINISHES: As cast, rough machined, or finished machined, including honing and grinding. Complete welding and machine shop facilities are available.

ACIPCO

SPECIAL PRODUCTS

DIVISION OF AMERICAN CAST IRON PIPE CO.

BIRMINGHAM · ALABAMA



a new approach to process computer control

Through **dynamic simulation**, Link offers you process computer control that . . .

- **permits** dynamic study of transients during process upsets or load changes.
- **operates** on inputs/outputs familiar to process engineers and operators.
- **provides** a convenient engineering tool for studying operating procedures and process revisions.
- **is designed** to represent complete process needs without simplifying process or providing excess computer capacity.
- **can be** installed with minimum revision to existing instrumentation.
- **utilizes** standard analog and digital building blocks functionally grouped to permit installation in stages.
- **allows** integration with other processes to increase the scope of computer control.

If you are looking for maximum return on a minimum capital investment, consider Link **dynamic simulation** for your computer process control. For specific details—or an engineering presentation—contact J. C. Croft, Manager, Industrial Control Products.

Another example of Link / Ability

LINK DIVISION
Binghamton, New York

GP

GENERAL PRECISION, INC.
Other Divisions: GPL, Kearfott, Librascope.

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Creole Petroleum Corp.
El Paso Natural Gas Products Co.
Trans-Arabian Pipe Line Co. (Arabia)
Petroleum Chemical Corp.
Iraq Petroleum Co. (Iraq)
Shelton Iron and Steel Co. (England)
Fullers Earth Union (England)
Multan Power Station (Pakistan)

Cia. Hidroelectrica de Rio Pardo (Brazil)
Union Carbide Caribe, Inc. (Puerto Rico)
Masonite Corp.
Industria Columbia de Fertilizante (Columbia)
Mayaguez Power Plant (Puerto Rico)
Itilities Co.
de Mexico
Barium Corp.
(Kuwait)
ta (Brazil)
Electria
la)
(Venezuela)
D-X Sunray Oil Co.
Mene Grande Oil (Venezuela)
Great Lakes Pipe Line Co.
Esso Standard Oil Co.
Champlin Oil Co.
Cia. Nacional de Electricidad (Mexico)
Vengrab Refinery (Venezuela)

These users feed their gas turbines* conditioned air by AAF!

*20,000,000 CFM representing 1,650,000 HP

Clean intake air for top operating efficiency — *cool* air for maintaining horsepower output!

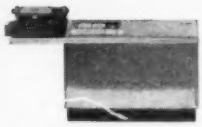
That's what these companies — and others — needed for their gas turbine installations. And their needs were met by American Air Filter — the *only* company with world-wide experience in applying intake air filters to gas turbines.

Whether your operation is in a torrid desert, frozen Arctic, or a temperate region — whatever the type of atmospheric contaminant — whether your application is process, pumping, or power — whether your station is automatic or attended, portable or stationary — **AAF** has air filtration equipment *engineered* to match your requirements!

For information on AAF's complete line of BETTER AIR products for gas turbine applications, write for Bulletin 150. Address: Mr. Robert Moore, American Air Filter Co., Inc., 452 Central Avenue, Louisville, Kentucky.

AAF American Air Filter
BETTER AIR IS OUR BUSINESS

For more data on advertised products, use Readers' Service Cards, last page.



LGP-30 COMPUTER ABSTRACTS

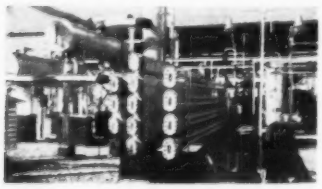
(Application Report #10, from which the following is abstracted, is free upon request from Royal McBee Corporation, Data Processing Division, Port Chester, N. Y.)

Subject: Design / User: Brown Fintube Company, Elyria, Ohio

THE PROBLEM: rush quotation for heat exchanger to potential customer. Determine best heat exchanger vs. cost combination. Perform necessary computations to obtain values for total surface area; total number of exchangers; area/exchanger; velocity and pressure drop—shell and tube; film coefficient; log mean temperature difference; overall transfer rate; clean rate; overall fouled rate; surface actually required; duty; price.

METHOD: the compact, low-cost Royal Precision LGP-30 Electronic Computer.

INPUT DATA: except for special specifications which are handled by design engineers, non-technical personnel fill in data directly from customer inquiry sheets. This information is then punched on tape.



SOLUTION: the engineer reads the above data into storage in specifically assigned memory locations on the computer's magnetic drum. The set of program instructions—also stored on the drum—then directs the computer where to find the input data and what mathematical operations to perform in the proper sequential order. The program then further directs the computer to store the various answers in specifically assigned memory locations.

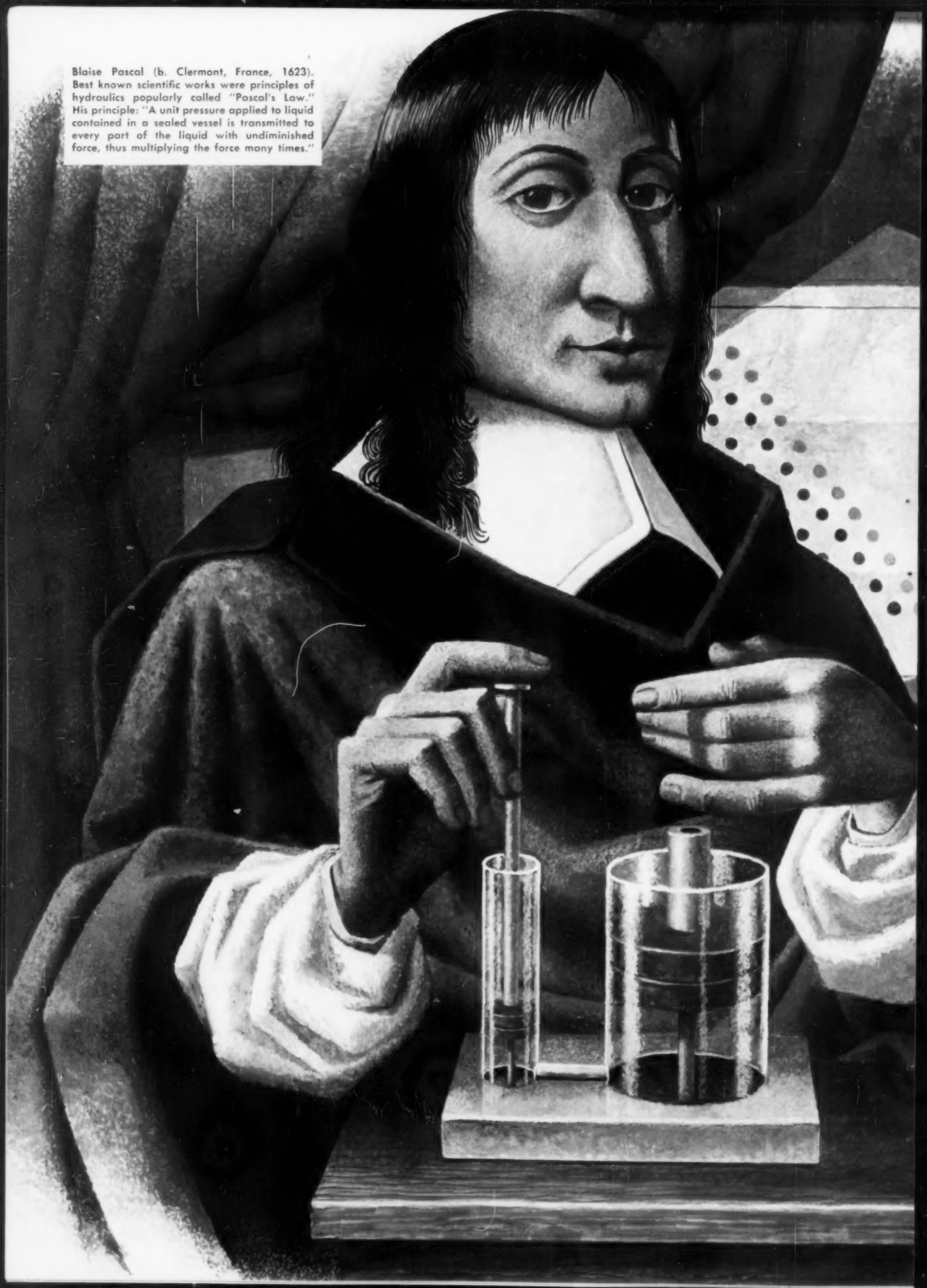
Of notable interest is the incorporated test feature which allows any type and arrangement of sections to be tested by the computer. The program not only compares calculated values, but provides a corrective computation and recomputes all conditions until satisfactory values are obtained. The engineer need only type in the exact arrangement desired to have the computer calculate his proposed arrangement – assuring complete versatility and control over the program.

OUTPUT: all numbers required for the final specification sheet, including price, are provided—as well as key intermediate answers to enable the engineer to exercise judgment. The computer automatically controls the typewriter so that all answers are printed out in the desired format.

CONCLUSIONS: with the LGP-30, Brown Fintube has reduced total time on typical heat exchanger designs from one or two hours to approximately 3 minutes. Better design vs. cost combinations have been obtained—with a resulting increase in contract awards and the elimination of under-bidding. According to company officials, "perhaps the most significant contribution of the LGP-30 has been the release of engineering manpower for more basic and profound studies."

Royal Precision Corporation

Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. LGP-30 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing offices. For your free copy of Application Report #10, as well as full specifications on the compact, mobile LGP-30, write today to **ROYAL McBEE CORPORATION,** data processing division, Port Chester, N.Y.



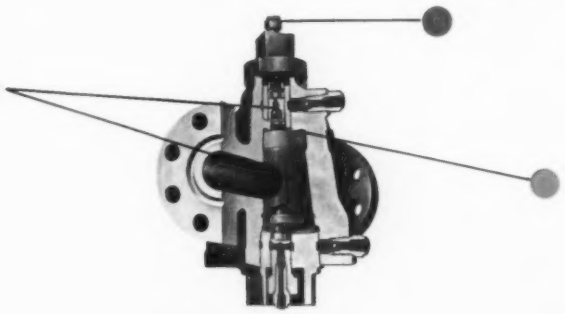
Blaise Pascal (b. Clermont, France, 1623). Best known scientific works were principles of hydraulics popularly called "Pascal's Law." His principle: "A unit pressure applied to liquid contained in a sealed vessel is transmitted to every part of the liquid with undiminished force, thus multiplying the force many times."

he gave the world new muscles

. . . and his idea helped give you a better valve

Blaise Pascal, through applied hydraulics, freed man from total dependence on his own muscles and the brute strength of animals. The list of modern devices that rely at least in part on hydraulics to multiply power is almost endless.

A perfect application of Pascal's principle is the Rockwell-Nordstrom lubricated plug valve. In it, *pressurized* lubricant jacks the tapered plug minutely from its seat to keep it free for instant ¼-turn operation. And pressurized lubricant in the Sealdport® grooves between the valve body and plug also creates powerful, positive seals against leakage . . . seals that can't be damaged like the exposed seats in other valves. For additional reasons why Rockwell-Nordstrom lubricated plug valves will give you better flow control at lower cost, examine the cutaway illustration below.



PERFECT APPLICATION OF A PRINCIPLE

- Lubricant quickly, easily injected through Rockwell fitting.
- Lubricant travels through Sealdport® system to create powerful seals against leakage and prevent metal-to-metal wear between plug and body . . . note seats never exposed to the line.
- Lubricant hydraulically jacks plug minutely from seat for instant quarter-turn operation.

Rockwell-Nordstrom is the original and world's most complete line of lubricated plug valves. Available in sizes from ½" to 36" and pressures to 15,000 lb. For additional information, see your supplier or write: Rockwell Manufacturing Company, Pittsburgh 8, Pennsylvania. Canadian Valve Licensee: Peacock Brothers Limited. If you live outside the USA, write: Rockwell International S.A., Geneva, Switzerland.

Lubrication Makes The Difference

ROCKWELL-Nordstrom VALVES

another fine product by

ROCKWELL

October is Gasoline Tax Reminder Month!

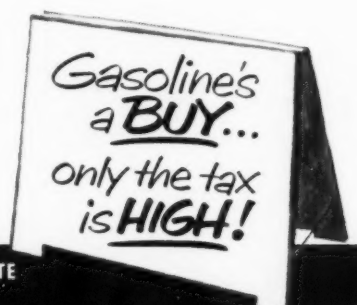
It's the anniversary of the latest temporary Federal gasoline tax increase!

Every oil man and woman should be keenly aware that October is gasoline tax reminder month. October 1, 1959, was the day the temporary 1¢ increase in the Federal gasoline tax went into effect, making the total Federal tax 4¢ a gallon. That's why October is an excellent time for you to remind your friends and business associates about high gasoline taxes. And make sure they know that Congress promised this temporary tax increase would expire on June 30th, 1961 . . . and the Federal tax revert to 3¢ a gallon.

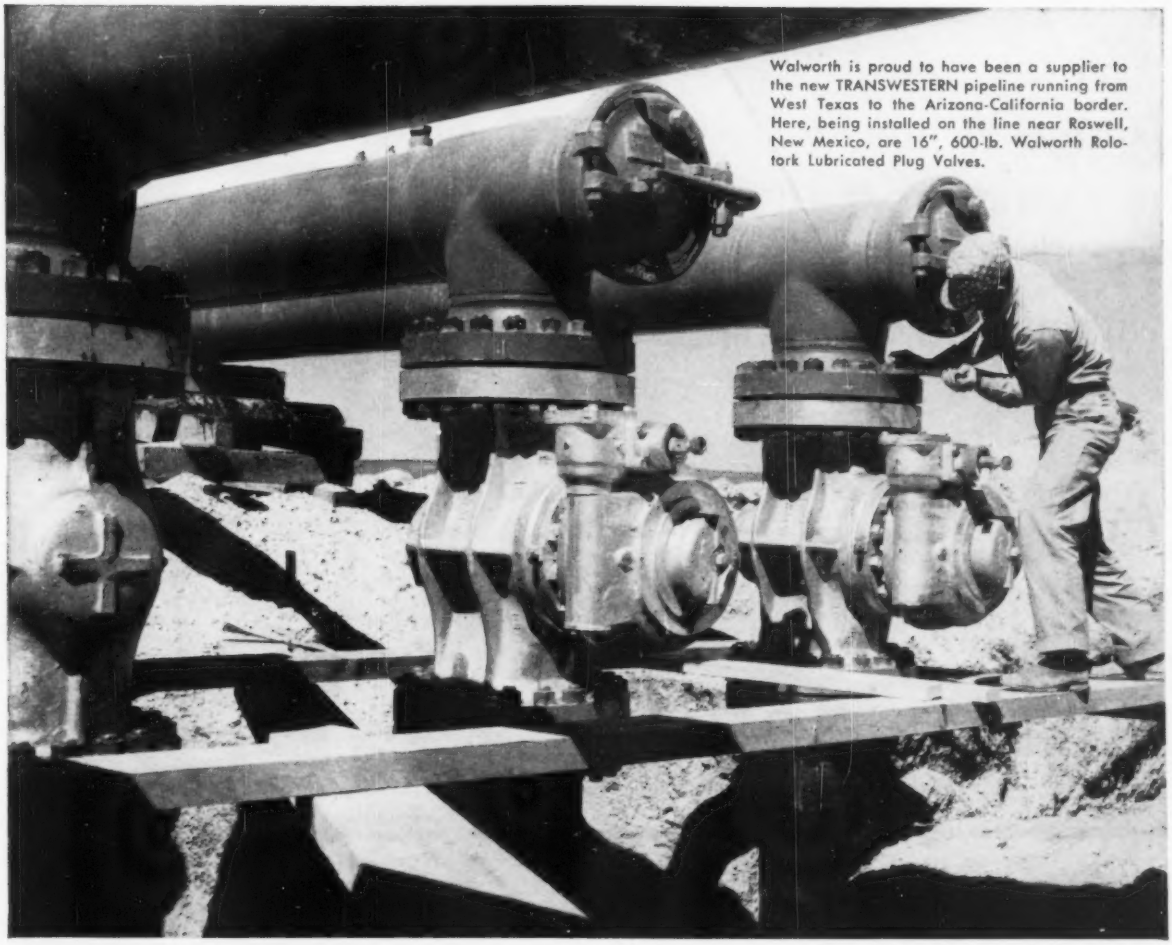
Here are the facts about high gasoline taxes that everyone should know:

- **Motorists pay about one dollar in taxes on every ten gallons of gasoline they buy!**
- **The gasoline tax rate is five times as high as the tax on luxuries like diamonds and mink coats!**
- **Motorists now pay about a 50% sales tax on gasoline!**

So, take advantage of this special gasoline tax reminder month and give your friends the facts about high gasoline taxes.

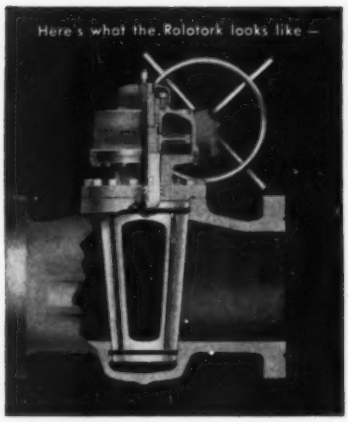


COMMITTEE ON PUBLIC AFFAIRS OF THE AMERICAN PETROLEUM INSTITUTE
1271 AVENUE OF THE AMERICAS, NEW YORK 20, NEW YORK



Walworth is proud to have been a supplier to the new TRANSWESTERN pipeline running from West Texas to the Arizona-California border. Here, being installed on the line near Roswell, New Mexico, are 16", 600-lb. Walworth Rolotork Lubricated Plug Valves.

RELY ON *ROLOTORK* ...BY WALWORTH



No matter what the service, you can rely on the Walworth Rolotork Lubricated Plug Valve to operate easily and dependably in handling gas, crude or finished petroleum products. In service throughout the world, these valves have proved their complete dependability. Why? Because Walworth manufactures a *better* LPV.

The Rolotork turns more easily, closes tighter, and requires less maintenance. It can be lubricated without removing the lubricant fitting. The gear housing design permits simple attachment of lubrication and handwheel extensions without modifying the gearcase. And vertical and circumferential lubricant grooves completely frame the port openings, preventing leakage.

These are just some of the features that make Walworth LPV's better. For additional information, write Walworth Company, Lubricated Plug Valve Division, 3517 Polk Avenue, Houston 23, Texas.

WALWORTH *750 Third Avenue, New York 17, N. Y.*

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

WALWORTH SUBSIDIARIES: ALLOY STEEL PRODUCTS CO. • CONOFLOW CORPORATION • GROVE VALVE AND REGULATOR CO. M&H VALVE & FITTINGS CO. • SOUTHWEST FABRICATING & WELDING CO., INC.

For more data on advertised products, use Readers' Service Cards, last page.

Badge of quality
in a gasoline
...it's blended
with an

AMOCO 530 Series Antioxidant

The AMOCO 530 Series of antioxidants includes the three principal gasoline antioxidant types. These products will effectively retard the formation of gum during the storage of your gasoline.

The AMOCO antioxidants have special additional advantages. Three of them—AMOCO 532, 533 and 534—are insensitive to both water and caustic. They stabilize TEL and prevent degradation as well as precipitation in storage. In addition AMOCO 532 may be used to inhibitor sweeten gasoline. AMOCO 533 is also an excellent antioxidant for industrial oils.

Petroleum additive specialists from AMOCO Chemicals will be happy to consult with you on your lubricating oil and gasoline additive programs. Your inquiry will receive prompt attention.

AMOCO 530 SERIES
Antioxidants
AMOCO 531—N-Butyl-p-aminophenol in isopropanol
AMOCO 532—N, N'-Disecbutyl-p-phenylenediamine
AMOCO 533—2,6-Diterbutylparacresol
AMOCO 534—2,6-Diterbutylparacresol in toluene

AMOCO CHEMICALS

AMOCO CHEMICALS CORPORATION
Department 4196
910 South Michigan Avenue, Chicago 80, Illinois

CHECK OIC FIRST...IT PAYS!

DEPENDABILITY is the *first* consideration when you choose a valve, because the cost of valve failure in down time is almost always greater than the cost of the valve itself. That's why so many of the best distributors sell the OIC line. They know that when they recommend OIC valves, their customers can depend upon them...even in those tough problem installations. Equally important is the distributor's own dependability... his capacity to deliver the valves you need, when you need them. Here, OIC offers the support of a complete factory inventory of bronze, iron, ductile iron, cast and forged-steel valves. You get immediate delivery from your OIC distributor's representative stock, and 4 to 5-day delivery from warehouse or factory. For dependability of product and service, phone your OIC distributor. He has our all-out support in serving you.

OIC VALVES

FORGED AND CAST STEEL, BRONZE, IRON AND DUCTILE IRON VALVES

THE OHIO INJECTOR COMPANY • WADSWORTH, OHIO

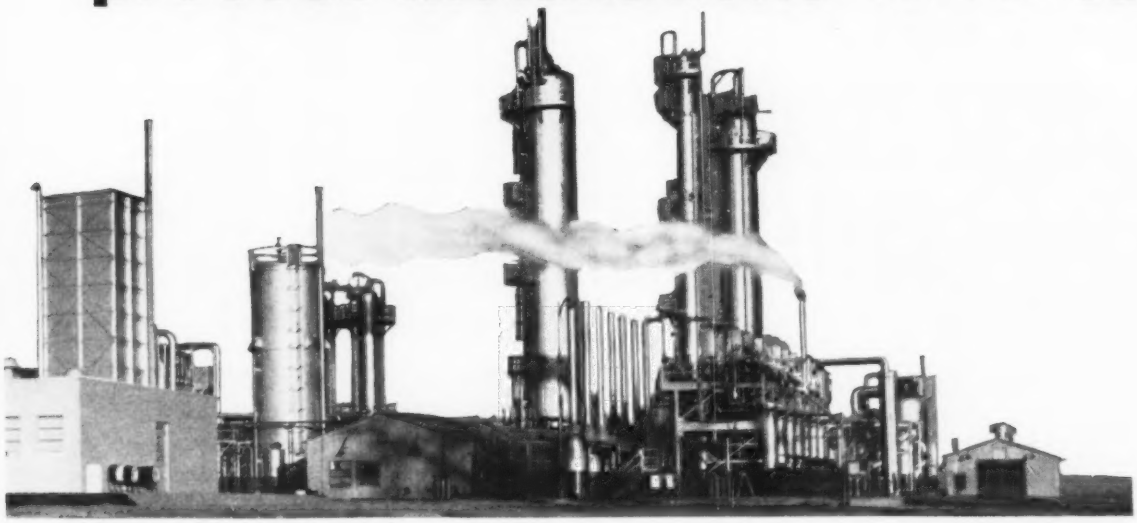
For more data on advertised products, use Readers' Service Cards, last page.

AMMONIA

FEED	NO. OF PLANTS	HYDROGEN PRODUCTION	NITROGEN SUPPLY	AMMONIA SYNTHESIS PROCESS	CAP. T/D	Location
BY-PRODUCT HYDROGEN	1	Oxygen Removal; NaOH Scrubber	Air Separation; N_2; O_2; Air	Casale	60	Michigan
ACETYLENE PLANT TAIL GAS	1	H_2O; Shift Conversion; CO_2 Removal; Liquid Nitrogen Wash	Air Separation; N_2; O_2; Air	Casale	110	Texas
HYDROGEN-RICH REFINERY OFF-GAS	2	H_2S Removal; CO_2 Removal; Low-temperature Fractionation and Liquid Nitrogen Wash; N_2	Air Separation; N_2; O_2; Air	2 Casale	380 180	Louisiana Illinois
NATURAL GAS (a)	5	O_2; Texaco Partial Oxidation; H_2O; Shift Conversion; CO_2 Removal; Liquid Nitrogen Wash; O_2; N_2	Air Separation; N_2; O_2; Air	4 Casale 1 Other	210 (b) 230 300 180 100	Mississippi Oklahoma Tennessee Kansas Brazil
OIL	2	O_2; Stm; Texaco Partial Oxidation; H_2O; Carbon Removal; H_2O; Shift Conversion; CO_2 Removal; Liquid Nitrogen Wash; O_2; N_2	Air Separation; N_2; O_2; Air	2 Others	110 (b) 120 (b)	Japan Japan
OIL (HIGH SULFUR)	2	O_2; Stm; Texaco Partial Oxidation; H_2O; Carbon Removal; H_2O; Sulfur Removal; Shift Conversion; CO_2 Removal; Liquid Nitrogen Wash	Air Separation; N_2; O_2; Air	1 Other	360 (b) 330	Spain Italy
NATURAL GAS	2	Steam; Air; H_2O; H_2S Removal; Steam Reforming; 1st Stage Shift Conversion; CO_2 Removal; H_2O; 2nd Stage Shift Conversion; CO_2 Removal; Methanation	From Secondary Reforming	2 Casale	200 115	Indonesia Iran
TOTAL	15	(a) Purification before oxidation not normally required. (b) Synthesis gas			2985	

For more data on advertised products, use Readers' Service Cards, last page.

process installations 1945-1960



Worldwide experience with six feeds utilizing seven process sequences to produce ammonia

More than one million tons per year ammonia capacity has been built or is under contract by Foster Wheeler. Eight Foster Wheeler plants account for 20% of the tremendous increase in the production of ammonia in the United States over the last decade. The table at left provides a brief view of FW's process flexibility and worldwide experience.

The most recently completed FW ammonia plant exceeded rated capacity within one month of start-up. Economic production over a wide range of outputs has been realized. From plants of modest size, to those in the higher capacity ranges, these Foster Wheeler ammonia plants turn in exceptional performances.

Foster Wheeler has also designed and constructed two of the largest urea plants in the United States. Both use the Pechiney-Grace process featuring total recycle and produce urea of superior quality and color. To get information on the ways Foster Wheeler process experience can serve you, write to Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, New York.

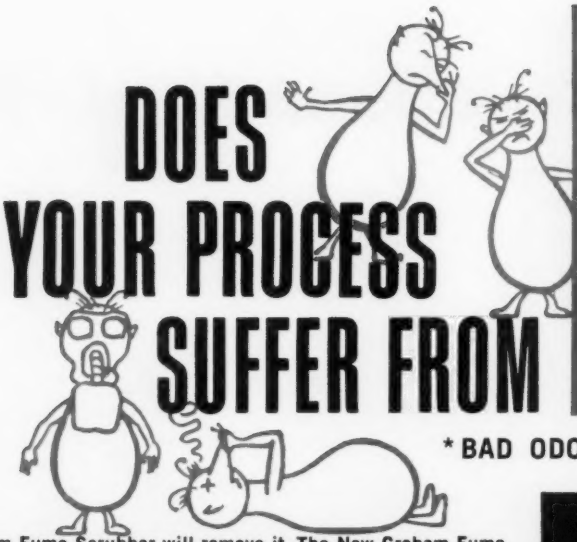
Heat Engineered products, plants and processes... for the world's industrial progress.

FOSTER WHEELER

NEW YORK LONDON PARIS ST. CATHARINES, ONT.

For more data on advertised products, use Readers' Service Cards, last page.

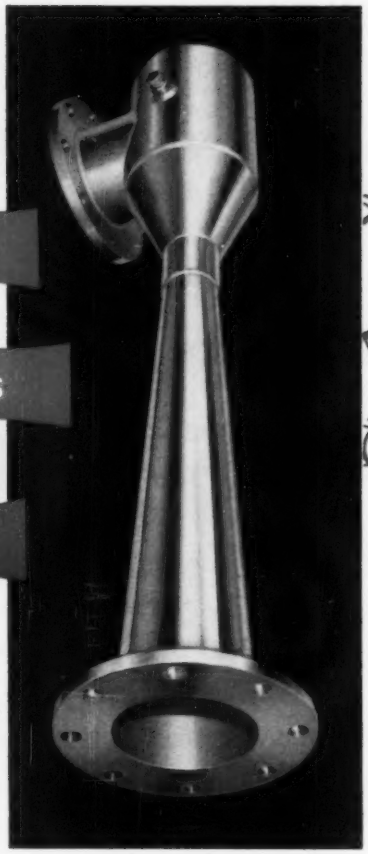
DOES YOUR PROCESS SUFFER FROM B.O.*?



*** BAD ODORS, DUST, VAPORS, ETC.**

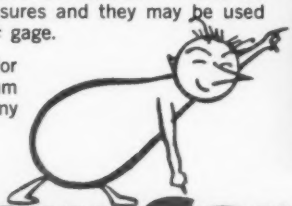
A Graham Fume Scrubber will remove it. The New Graham Fume Scrubbers are a modern concept of the water-operated vacuum jet. Here is what they can do for you —

1. REMOVE GAS, VAPORS AND DUST FROM ANY SPACE
2. PREVENT ATMOSPHERIC CONTAMINATION
3. RECOVER VALUABLE PRODUCTS
4. PROVIDE DRAFT ON COMBUSTION FURNACES
5. CLEAN AND PURIFY THE AIR IN WORKING AREAS
6. USE AS A GAS-LIQUID REACTOR



Graham Fume Scrubbers are manufactured in any alloy that is required for your application and are therefore corrosion resistant against any material you are processing. They are made in three different designs for the most economical use of water over a wide range of suction pressures and they may be used with water pressures as low as 10# gage.

If you have a fume, dust or odor problem contact your nearest Graham factory-trained representative in any of the following cities.



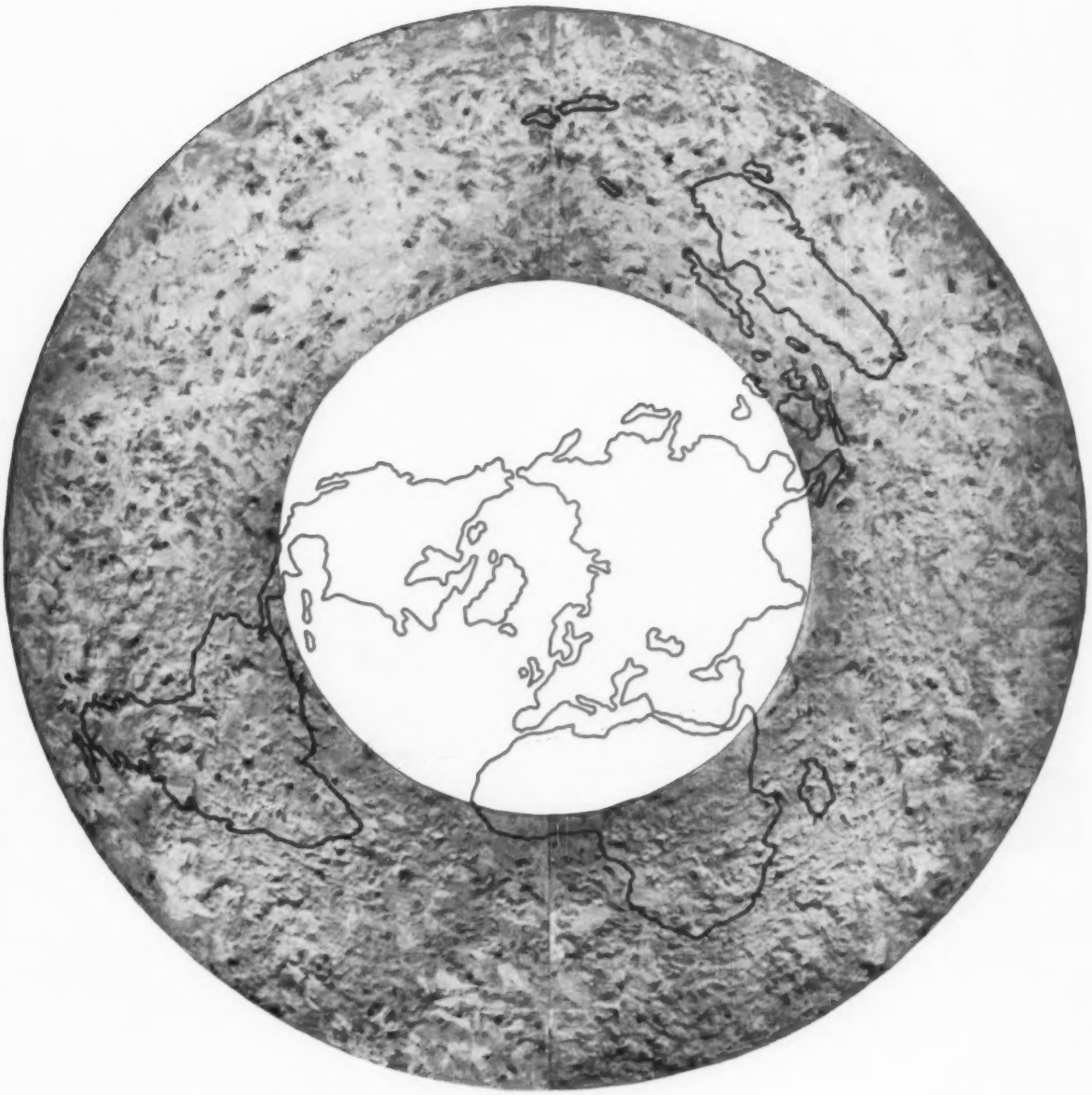
Heliflow Corporation

GRAHAM MANUFACTURING CO., INC.

170 GREAT NECK ROAD • GREAT NECK, N. Y.

Factory: Batavia, N. Y.
Other Graham precision-built products:
Steam Jet Ejectors,
Heliflow Heat Exchangers,
Monobolt Heat Exchangers,
Deaerating Heaters, Surface and Barometric Condensers,
Steam Vacuum Refrigeration,
Aquadyne Evaporative Condensers,
Panaflow Exchangers.

Albuquerque, N. Mex.
Atlanta, Ga.
Baltimore, Md.
Boston, Mass.
Buffalo, N. Y.
Chicago, Ill.
Cincinnati, O.
Cleveland, O.
Coral Gables, Fla.
Denver, Colo.
Detroit, Mich.
Hato Rey, P. R.
Honolulu, Hawaii
Houston, Tex.
Kansas City, Mo.
Los Angeles, Calif.
Mexico, D. F., Mex.
Minneapolis, Minn.
Tulsa, Okla.
Mobile, Ala.
Philadelphia, Pa.
Phoenix, Ariz.
Pittsburgh, Pa.
Richmond, Va.
Roanoke, Va.
San Francisco, Calif.
Seattle, Wash.
St. Louis, Mo.
Toronto, Ont.



made the world over

—and to the same specification

Caposite amosite asbestos is manufactured under supervision to the same uniform specification in all these countries.

Great Britain	by The Cape Asbestos Company Ltd
Canada	by Caposite Insulations Ltd
South Africa	by Cape Asbestos Insulations (Pty) Ltd
Australia	by James Hardie & Company Ltd.
France (as 'Isolamiante')	by Isolamiante SA
Italy	by Capamianto SpA
Holland	by J. de Boer & Company
Spain	by Messrs. Eduardo Rosa
Argentina	by Montisol Argentina. SRL
Japan	by Nippon Asbestos Company

Amosite asbestos insulation is also manufactured in U.S.A. under the name of 'Unibestos' by Union Asbestos Rubber Company.

CAPOSITE regd.

AMOSITE ASBESTOS INSULATION

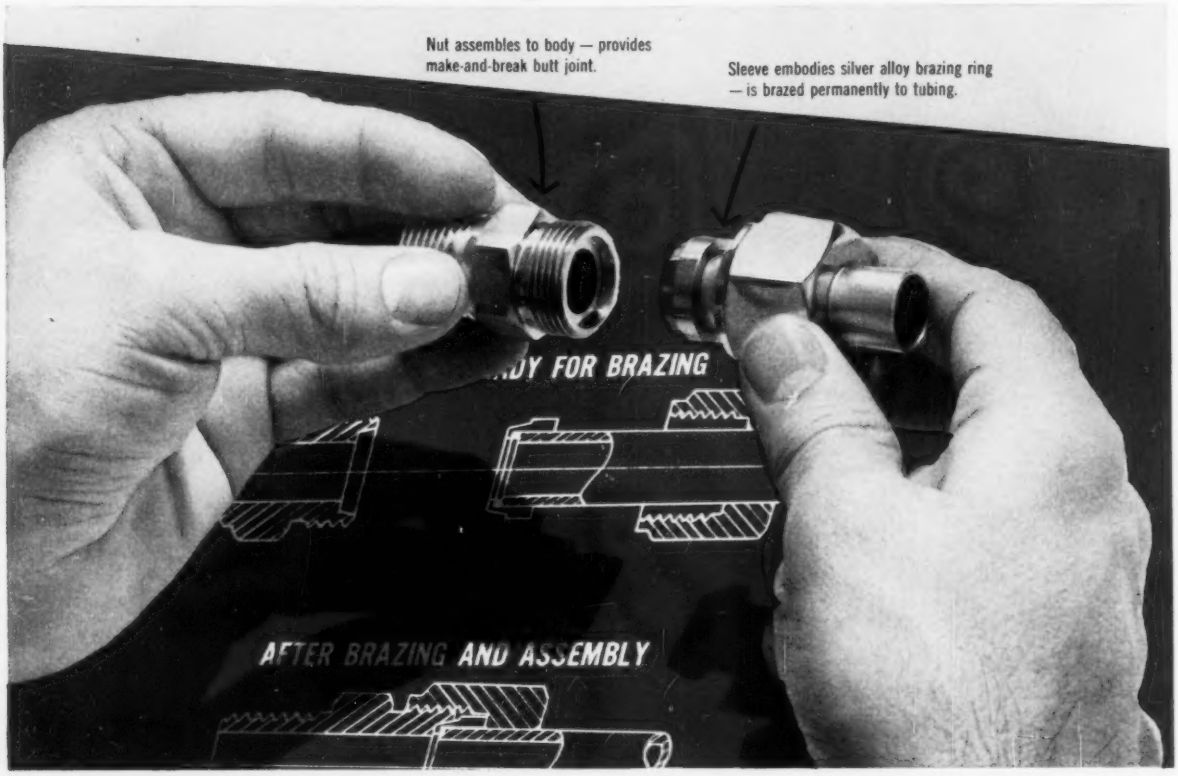
CAPE

THE **Cape Asbestos** COMPANY LTD 114 & 116 Park St. London W1. Grosvenor 6022

Enquiries to: Cape Asbestos (Canada) Limited, 200 Bloor Street East, Toronto, Ontario. North American Asbestos Corporation, Board of Trade Building, Chicago 4, Illinois. Capamianto SpA via Sant' Antonino 57, Turin, Italy.

TA.3612

IMPERIAL
Engineering and Data File


Nut assembles to body — provides make-and-break butt joint.
Sleeve embodies silver alloy brazing ring — is brazed permanently to tubing.
AFTER BRAZING AND ASSEMBLY

NEW BRAZE-SEAL TUBE FITTING

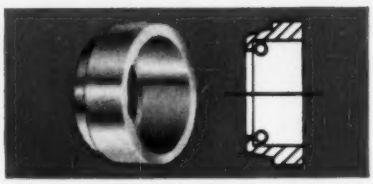
WITHSTANDS SUPER-PRESSURES, HIGH TEMPERATURES . . . RETAINS MAKE-AND-BREAK CONVENIENCE

Until Imperial Braze-Seal came along, engineers could not specify an economical make-and-break fitting for tubing circuits involving super-pressures and high temperatures. Applications like these called for welded connections. But now Braze-Seal offers high reliability, even under extreme pressures. (See chart below.)

MAXIMUM DESIGN PRESSURES (PSI) FOR BRAZE-SEAL FITTINGS

Tube O.D.	316 Stainless	Carbon Steel
3/8"	64,000	48,000
1/2"	62,400	46,800
9/16"	61,600	
5/8"	61,600	46,200
3/4"	60,000	45,000
7/8"	56,000	42,000
1"	52,000	39,000
1-1/4"	48,000	36,000
1-1/2"	44,000	33,000

Application of the following safety factor is recommended: 4 to 1, for sizes up to ¾" O.D.; 6 to 1, for sizes ¾" to 1½" O.D.



This Braze-Seal Sleeve, containing a silver alloy brazing ring, is the key to the performance of the Braze-Seal Fitting. It assures a joint that will withstand these extreme pressures because it is permanently brazed to tubing. Yet the fitting provides the convenience of a make-and-break butt joint, as illustrated, and is extremely easy to assemble.

Reducing Sleeves Provide Versatility

Can be furnished to reduce any size Braze-Seal tube end to any specified tube size. Extremely convenient on tees, for example, where any size tubing can be connected to the same tee body. Also, the same body may be used for making up flareless Hi-Seal fitting joints.

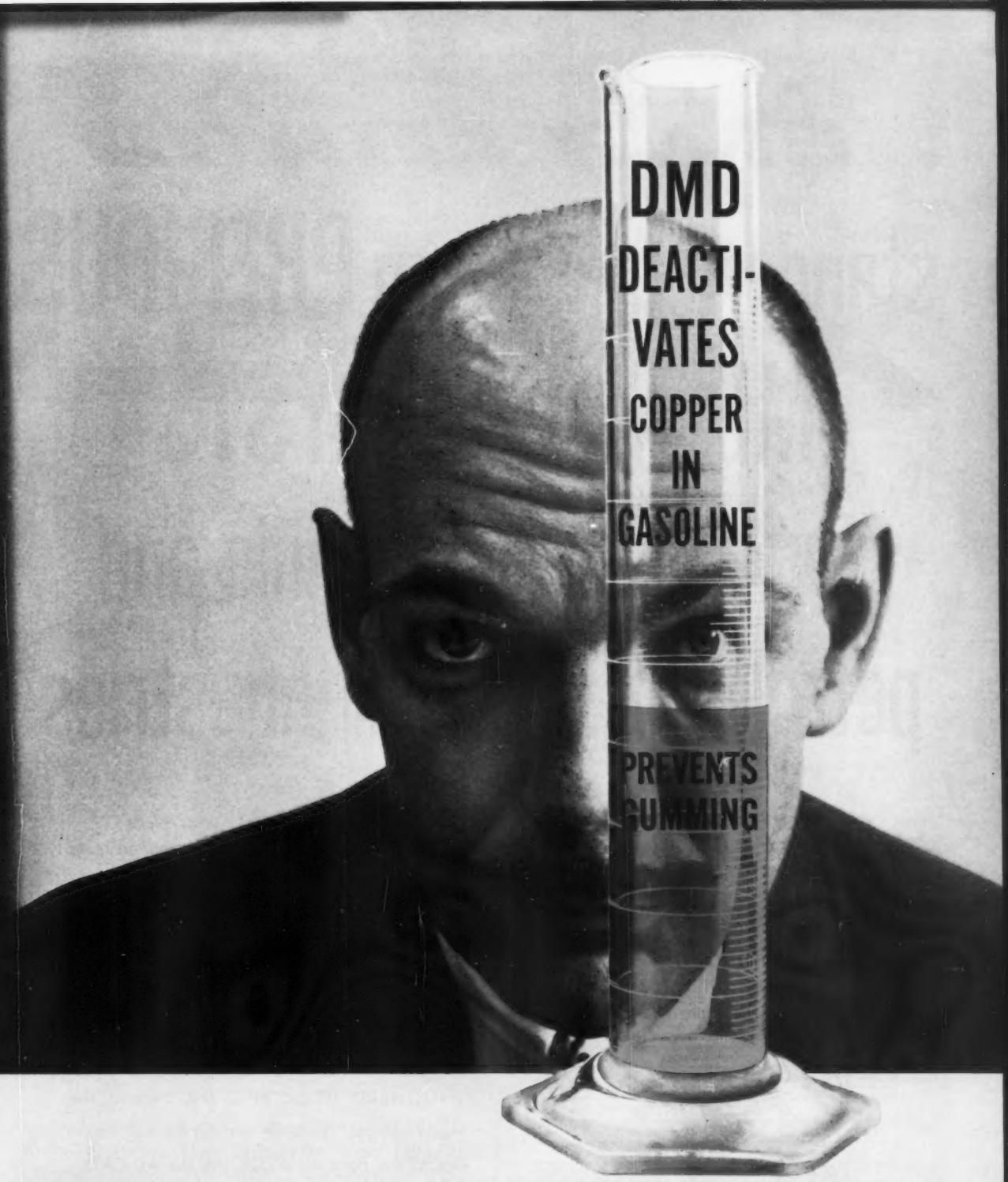
Imperial Braze-Seal Tube Fittings can be furnished in steel or stainless steel.

Check the outstanding features of Braze-Seal for yourself. Send for a sample fitting. See how Braze-Seal can help you solve the most difficult problems in super-pressure and high-temperature tube circuitry.

IT'S IN THE BOOK

Braze-Seal Fittings are covered in Imperial's new Hi-Seal Catalog — the most comprehensive coverage available on the subject of fittings, a hard-working handbook for engineers. Send for your copy today.

THE IMPERIAL BRASS MANUFACTURING CO.
Dept PR-100, 6300 West Howard Street
Chicago 48, Illinois 8-60



HERE IS ENOUGH (3 ounces) Du Pont Metal Deactivator to prevent copper-caused gumming in 8000 gallons of gasoline. ■ Somewhere, somehow, nearly every gallon of the gasoline, kerosine, jet or diesel fuel you produce will come in contact with at least a tiny bit of copper. Can't be helped. ■ By adding DMD to the fuel, you convert any dissolved copper into harmless chelate complexes. Result? No gum, no loss of product quality, no complaints. ■ This additive, which Du Pont pioneered 20 years ago, is still the best metal deactivator known to petroleum science. And as you can see, a little goes a long way. Figure the economics for yourself, or ask us to. ■ E. I. du Pont de Nemours & Co. (Inc.), Petroleum Chemicals Division, Wilmington 98, Delaware.

DU PONT

LEAD ANTIKNOCK COMPOUNDS and OTHER PETROLEUM ADDITIVES

Better Things for Better Living... *through Chemistry*

standard or custom PRECIOUS METAL CATALYSTS for use in the organic and petroleum chemical industries

Engelhard PRECIOUS METAL CATALYSTS are available...on a wide variety of carriers ...in the form best suited for your needs...in the concentration most economical for your purpose

ENGELHARD'S MOST WIDELY USED SPECIES

	ALUMINA-SUPPORTED CATALYSTS
5%	Pt, Pd, or Rh on alumina powder
0.5%	Pt, Pd, Rh, or Ru on ⅛" alumina pellets or spheres
0.3%	Pt on ⅛" alumina pellets or spheres

	CARBON-SUPPORTED CATALYSTS
5%	Pt or Pd on activated carbon powder
5%	Rh or Ru on carbon powder
0.2%	Pd on granular carbon

	OTHER CATALYST SPECIES
5%	Pd on $CaCO_3$ or $BaSO_4$ powder
	Pd or Pt oxide
	Pd or Pt black
	RD 150 or RD 150C

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NOW... MAKE HIGH-VALUE GASOLINE

FROM LOW-VALUE DISTILLATES

with the versatile
new UOP process...

LOMAX

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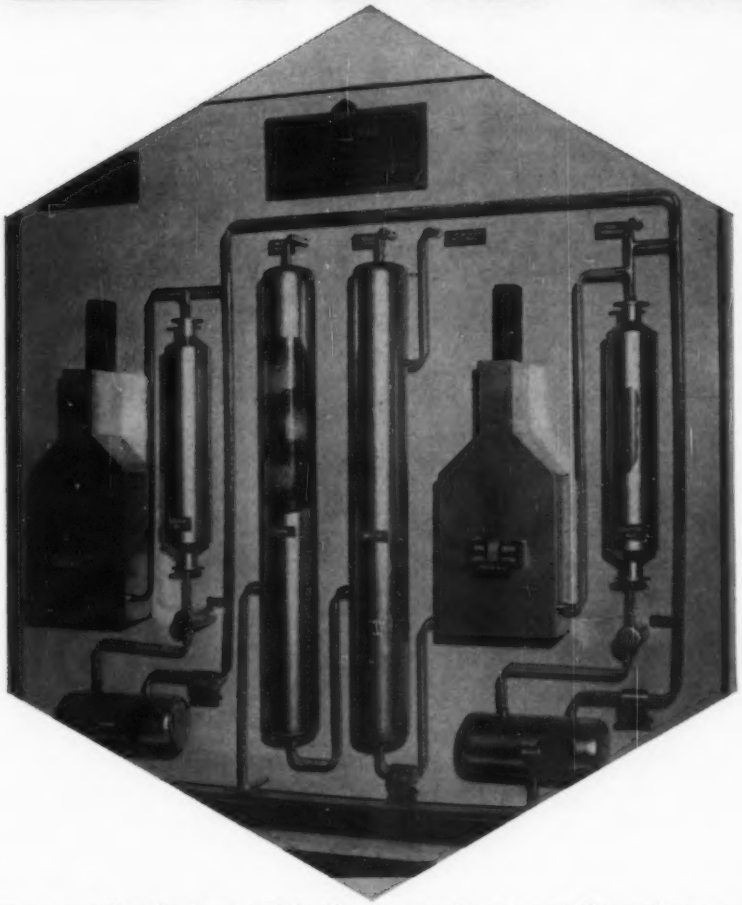

Model of LOMAX process which produces exceptionally pure, olefin-free products, a predominance of branched isomers—with greatly reduced quantities of light gases plus other important benefits.

Are you suffering from an overabundance of middle distillates? Or producing more vacuum gas oil than you know what to do with? Then your answer may be LOMAX, the flexible new UOP process that lets you make what you want *when you can sell it!*

Through reaction of hydrocarbons with hydrogen in the presence of a new UOP catalyst, LOMAX converts middle distillates into gasoline and distillate fuels—in just about *any ratio you want.* You make as much of each as you can sell, no more, no less.

UOP's highly flexible new LOMAX process may be used to supplement existing facilities, or as a basic cracking operation in a new installation. UOP engineers will work with you in preparing a case study showing how LOMAX will fit into your refining picture. Write, wire or phone for details.

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WHERE RESEARCH TODAY MEANS PROGRESS TOMORROW

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How the bottleneck in packed tower Support Plates and Distributors

When towers were filled with the packings available a few years ago, a plate with a few holes was all that was needed to support the packing, and a few streams of liquid all that was needed to wet it.

Low in efficiency, low in capacity, low in flooding limits, the packing itself was the bottleneck to effective mass transfer.

But the bottleneck shifted from packings to support plates and distributors when high-efficiency, high-capacity packings, such as Intalox Saddles and Pall Rings, were developed. Higher flooding limits of the new packings were meaningless with the low flooding limits of the available support plates. Higher gas handling capacities of the new packings were stymied by the poor gas handling capacity of the support plate. The greater surface area and better internal distribution characteristics of the new packings could not be used to their maximum value because of poor initial distribution from the distributor plates available.

Our engineers went to work. Scale models of design after design were given preliminary tests in a four inch tower. Those that showed promise were made in a 30″ size and subjected to test run after test run in our large experimental towers. Field experience in towers up to 10′ in diameter was then evaluated against our test findings.

The "gas-injection" principle in support plates was one result of this intensive program. The "weir-flow" principle in distributor plates was another.

Today, U. S. Stoneware produces a wide range of support plates and distributors based on these principles which permit the engineer to utilize to the full the high performance characteristics of Intalox Saddles and Pall Rings in effecting mass transfer.

A few of these *are* illustrated and described briefly on these two pages. Full technical data is given in Engineering Manual TA-40 sent free on request.

FOR HIGHEST EFFICIENCY, HIGHEST CAPACITY COUPLE "U. S." TOWER PACKING WITH "U. S." TOWER ACCESSORIES

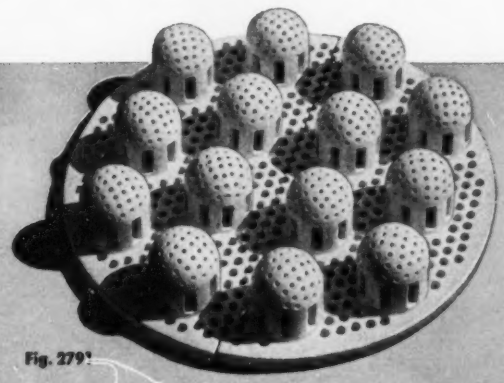

Fig. 279¹

CERAMIC "GAS-INJECTION" SUPPORT PLATE
Slotted risers with perforated caps inject the gas into the tower. Liquid leaves the column through holes in the base plate. All plates through a size range from 12" through 60" have an effective working free area of better than 50%.

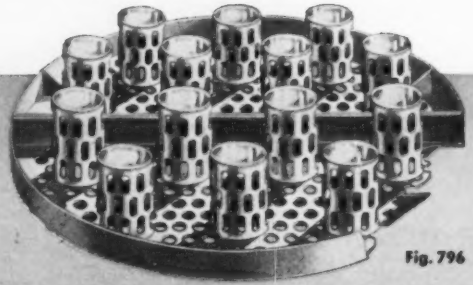

Fig. 796

METAL "GAS-INJECTION" SUPPORT PLATE
Similar in design to Fig. 2791; for towers from 4" dia. through 48"; percentage of free area generally exceeds 75%. Available in carbon steel, stainless steels, aluminum, copper, nickel, or any of the weldable alloys.

"WEIR-FLOW" CERAMIC DISTRIBUTOR
Cylindrical risers with "V" notches serve as downcomers for liquid, permitting greater flow as the head rises. The plate is supported on lugs which permit an annular space between distributor and tower wall through which gas rises. Ceramic "weir-flow" distributors are available for towers from 24" dia. through 96".

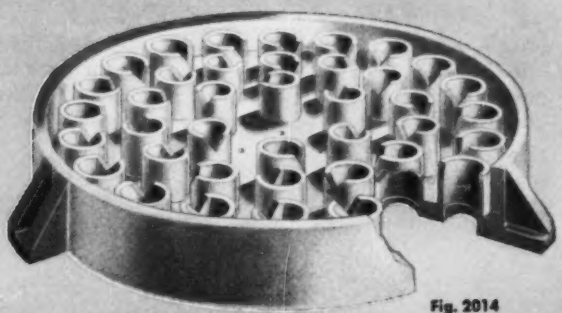

Fig. 2014

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performance shifted to
AND WHAT WE HAVE DONE ABOUT IT!

"MULTI-BEAM" METAL SUPPORT PLATE
With a free area generally exceeding 85%, this "gas-injection" design principle is available in separate metal beams to fit towers up to ten feet or more in diameter. Number of sections vary from three to ten.

SPECIAL SUPPORT PLATES
Special support plates incorporating the "gas-injection" principle are available fabricated from impervious graphite, fiberglass reinforced polyester resin, or titanium.

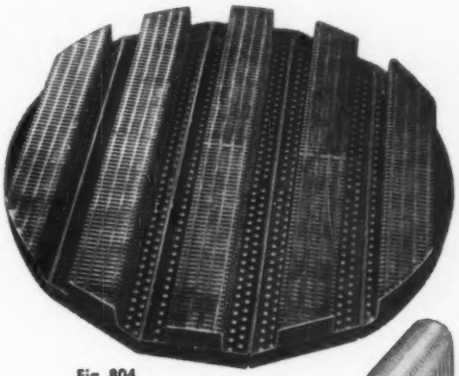


Fig. 804

METAL "WEIR-FLOW" DISTRIBUTORS
The basic "weir-flow" principle is shown here incorporated into a sectionalized metal distributor. Plates of this type can be made to fit towers of unlimited size. Metal "weir-flow" distributors are also available in one- or two-piece construction for towers up to 48" in diameter.

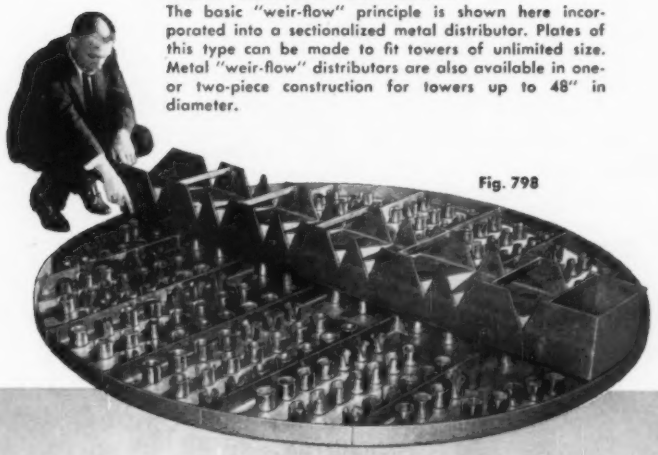


Fig. 798

"MULTI-BEAM" CERAMIC SUPPORT PLATE

Fig. 2808

For towers of 24" diameter up through 108". Made in the form of multiple beams for installation through manways. Has twice the load bearing capacity of Fig. 2791, even greater free area, yet retains all the advantages of the "gas-injection" principle.

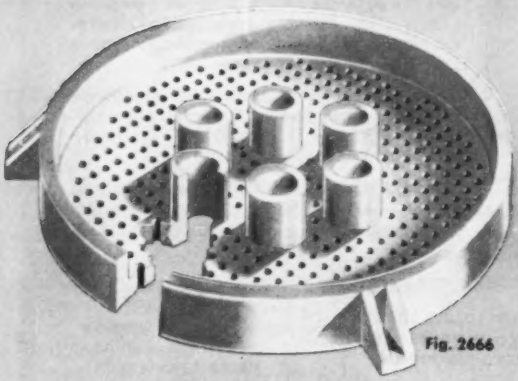
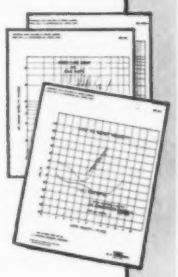


Fig. 2666

CERAMIC "ORIFICE" DISTRIBUTOR
This new distributor, on which patents are pending, is unique in that it offers the user a choice of three liquid rate ranges, enabling him to match his distributor to his flow requirements. For example, in a size to fit a 48" tower, Fig. 2666 is available for a liquid rate ranging from 12 to 50 gpm., or from 50 to 113 gpm., or from 113 to 414 gpm. This new distributor is made in chemical porcelain or in heat-shock resistant chemical stoneware in sizes to fit towers from 10" in dia. through 60".

ARE YOU RECEIVING THESE REPORTS FROM OUR CONTINUING RESEARCH INTO PACKED TOWER PERFORMANCE?



In our engineering laboratories, in a series of absorption and distillation towers up to 30" in diameter, we are continually evaluating the performance of tower packing and tower accessories under a wide range of operating conditions. If you would like copies of these studies please write us on your letterhead. Ask, too, for a copy of Engineering Manual TA-40.

Process Equipment Division

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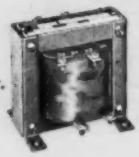
SQUARE D SPIN TOP® ENCLOSURE NOW MORE VERSATILE THAN EVER!

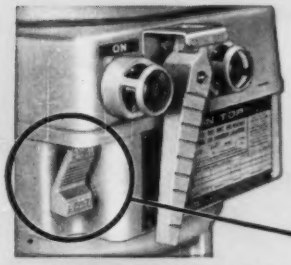
DAMAGE-RESISTING Acme threads. If you've struggled with "banged-up" threads, you'll appreciate this feature. It's always a breeze to put on and take off tanks for installation, inspection or maintenance.

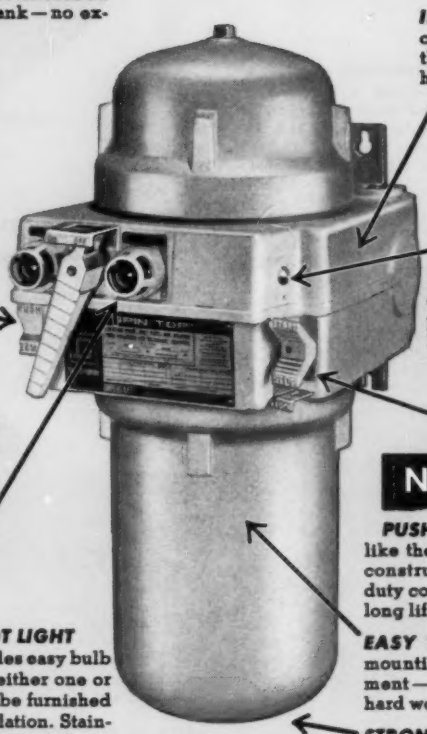
FULL WEATHER PROTECTION • Male threads on collar engage female threads on tank—no external threads to be damaged.

NEW! ***CONTROL TRANSFORMER*** can be mounted in collar. No special-length tanks required.



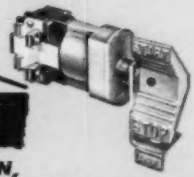
INCREASED WIRING SPACE • Four conduit openings standard, with through-feed conduit entrances for horizontal tap-offs optional.





NEW! ***SELECTOR SWITCH*** is made in one piece, installs simply by threading into opening provided in enclosure. One-piece construction permits pre-testing before shipment.

NEW! ***RECESSED CONTROL STATIONS*** like the reset button are out of the way, have no protrusion to break or bend accidentally.



NEW! ***PUSHBUTTON,*** like the selector switch, features one-piece construction for easy installation. Heavy-duty contacts and rugged mechanism assure long life.

NEW! ***BRILLIANT PILOT LIGHT*** is visible from all angles and provides easy bulb change. Enclosure available with either one or two factory-mounted lights or can be furnished with plugged holes for field installation. Stainless steel thread-in-thread construction gives corrosion-resistance and easy servicing.

EASY TO INSTALL with *slide and hook* mounting arrangement for interior equipment—a Square D "exclusive." Takes the hard work out of the installation job.

STRONG AND LIGHTWEIGHT construction. Complete enclosure is cast aluminum. All operating shafts are stainless steel, thread-in-thread, for the best in corrosion resistance.

Square D *is Better in So Many Ways!*

When you buy from Square D, you not only get all the benefits shown above—you also are buying from the only manufacturer who builds both the enclosure and the starter, giving you unit responsibility. Moreover, Square D offers better stocks, better on-the-spot service. That's why it makes sense to insist on Square D Spin Top enclosures for your hazardous location applications.

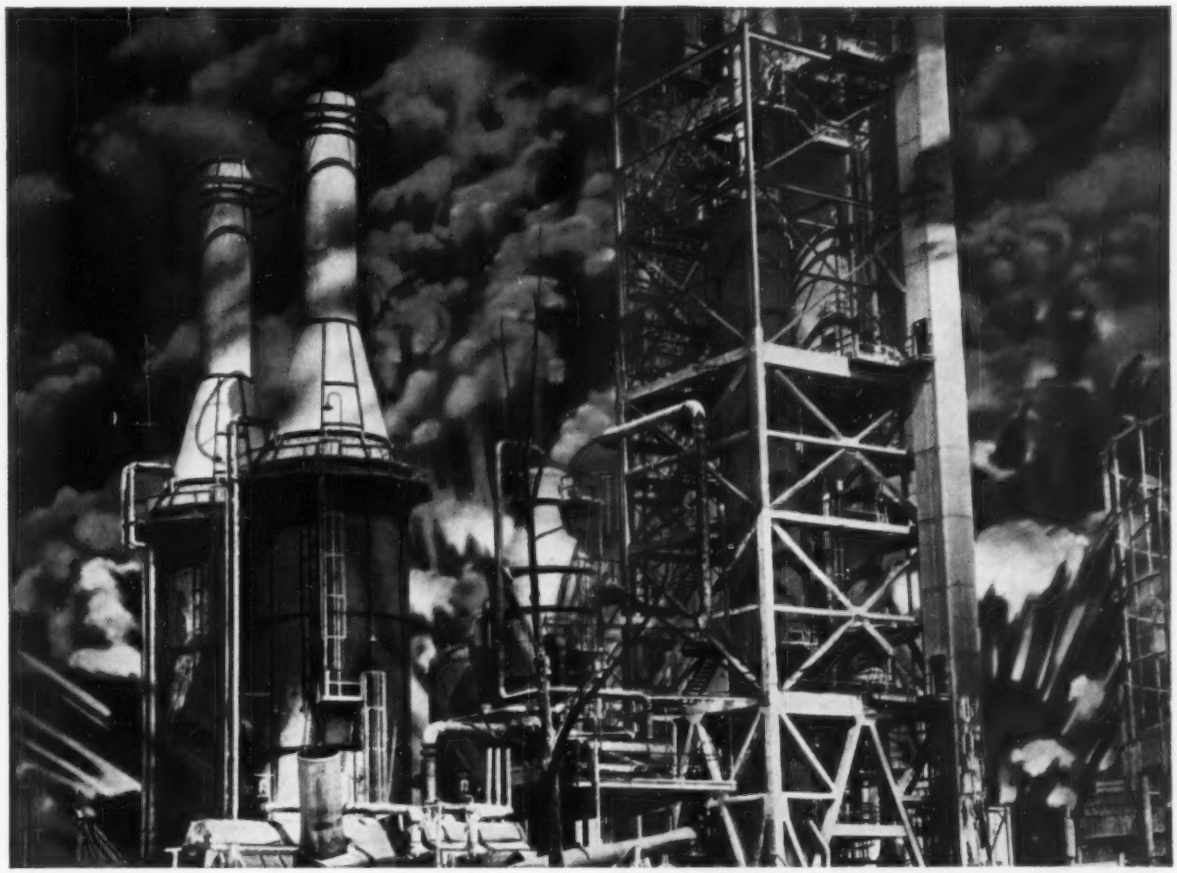
4 ENCLOSURE SIZES ACCOMMODATE NEMA SIZES 0 THROUGH 5

Square D Spin Top enclosures are NEMA 3 (weatherproof), NEMA 4 (watertight), NEMA 7 (explosion-proof) and NEMA 9 (hazardous locations) for Class I, Group C and D; and Class II, Groups E, F and G service.

Write **for Bulletin 9990. Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin**

SQUARE D COMPANY

wherever electricity is distributed and controlled



Protected by L. W. Blazecrete—this structure was virtually undamaged by 2 to 6 hours of *direct* flame exposure

Protected by Johns-Manville L. W. Blazecrete . . .

vital equipment is undamaged by 3 days of explosive fire!

AFTER MORE than seventy hours of fire and explosion had spread from storage tanks to one of the world's most modern thermofor catalytic plants, damage was estimated at nearly 8 million dollars.

Yet the flames didn't destroy the entire plant. Vital equipment, key structural members and control areas . . . made fire safe by J-M's L. W. Blazecrete®. . . were virtually undamaged. This simple, low-cost protection paid for itself countless times over by providing an effective shield against 2 to 6 hours of direct flame exposure.

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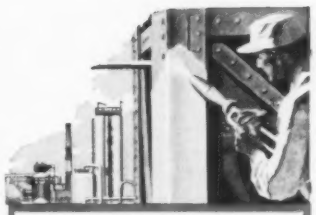
A hydraulic-setting refractory—Johns-Manville L. W. Blazecrete is quickly, easily applied to equipment and structural members . . . and to linings of high-temperature equipment. For troweling, just mix L. W. Blazecrete with water as you'd mix ordinary concrete—then slap trowel in place. When gunned, L. W. Blazecrete adheres readily with a minimum of rebound loss. Whether used for fire protection or for linings—L. W. *Blazecrete lasts!*

Find out more about this newest of fire protection ideas, and about the application of L. W. Blazecrete throughout the petroleum industry. Write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.



Gunned in place or slap troweled L. W. Blazecrete is the ideal material for refractory linings. It gives you an unusually strong, dense and homogeneous lining . . . ready for use within 24 hours.

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JOHNS-MANVILLE JM PRODUCTS

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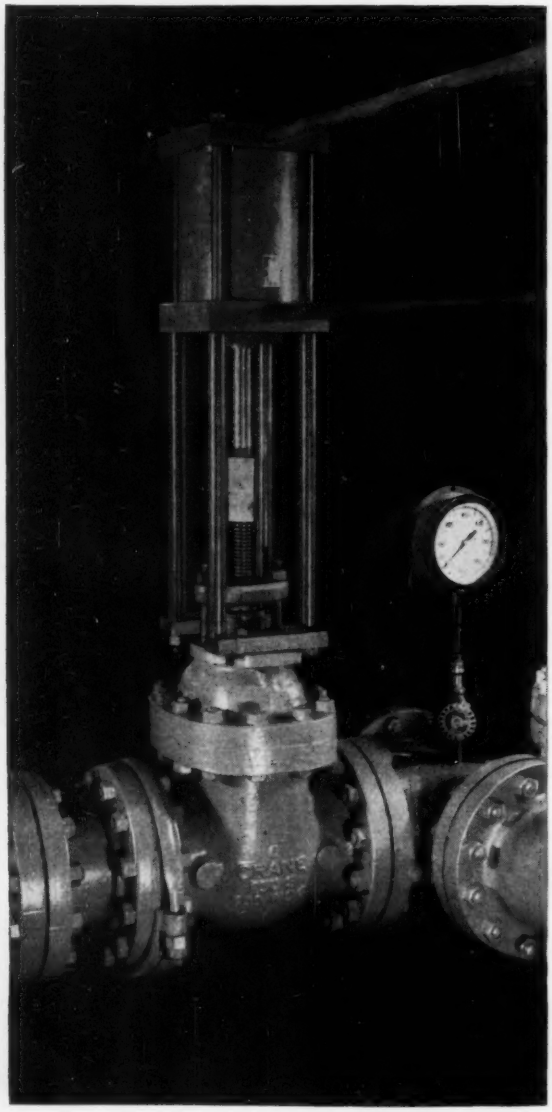
NEW CRANE CYLINDER OPERATORS— LOW-COST POWER OPERATION FOR GATE VALVES



Now you can control any flow process easier and faster with cylinder operated Crane valves. Large valves . . . valves in remote or inaccessible locations . . . valves that must be cycled many times a day . . . all these can now be operated at the touch of a finger, saving time and manpower. These benefits of power operation are available from Crane now—at lower cost and in less time than ever before!

Crane cylinder operators are available for Crane O. S. & Y. iron body wedge and double-disc gate valves, and for pulp stock valves. Control devices for local or remote actuation supplied at extra cost.

And you can get these new operators for modernization of your present Crane gate valves, too. Easy-to-install adapter is shipped with every cylinder. Field installation can be done in 30 minutes or less, without removing the valve from the line.

This new valve operator is another example of how Crane solves your flow problems more economically, more productively. The Crane solution—the right answer to your flow problems—is as close as a phone call to your Crane distributor. Call him today.

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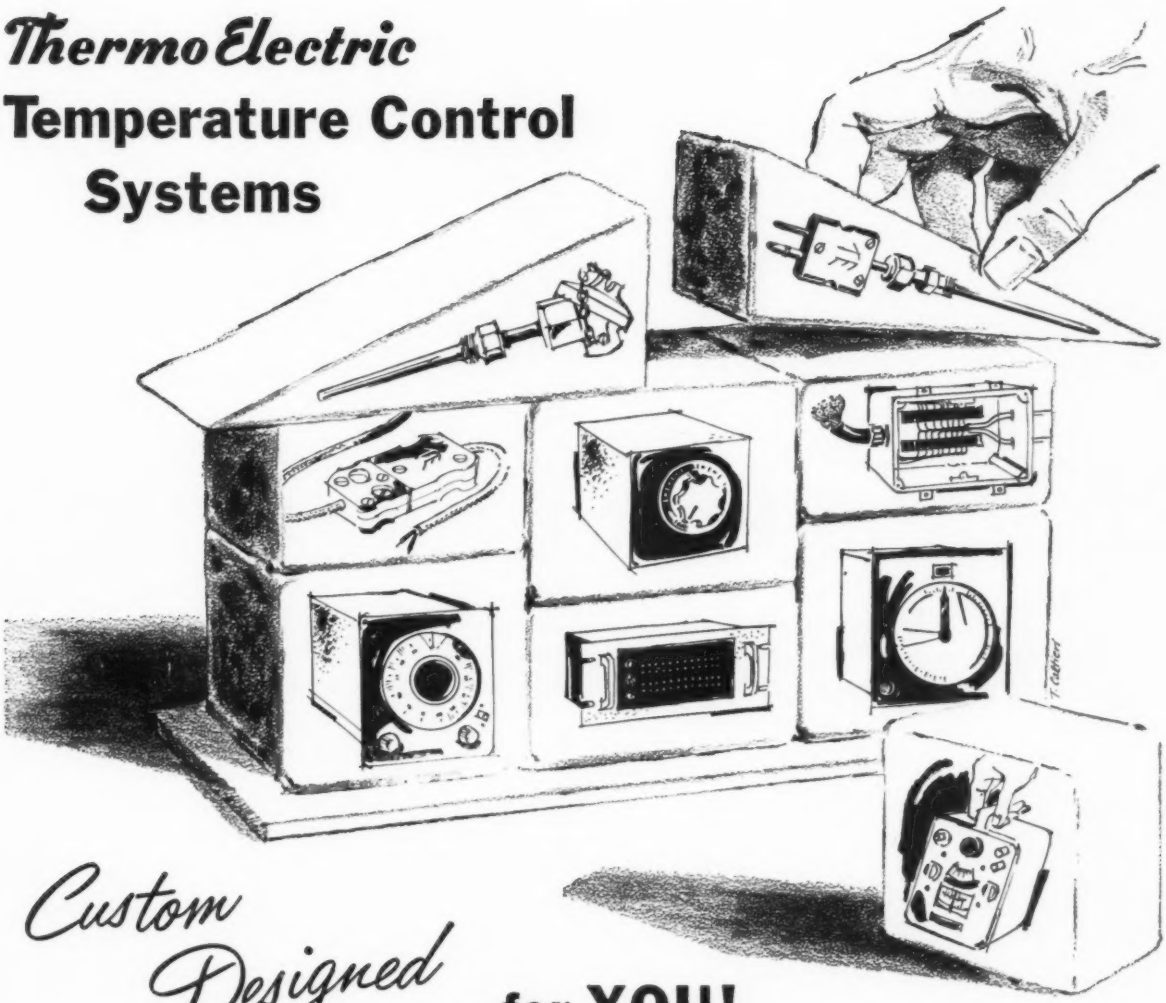
Thermo Electric Temperature Control Systems



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The portable "MiniMite" Indicator with 23" scale and 0.25% scale accuracy, can be used to indicate on-the-spot temperature or for calibration and test work.

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Send application details on your letterhead today to Dept. 19

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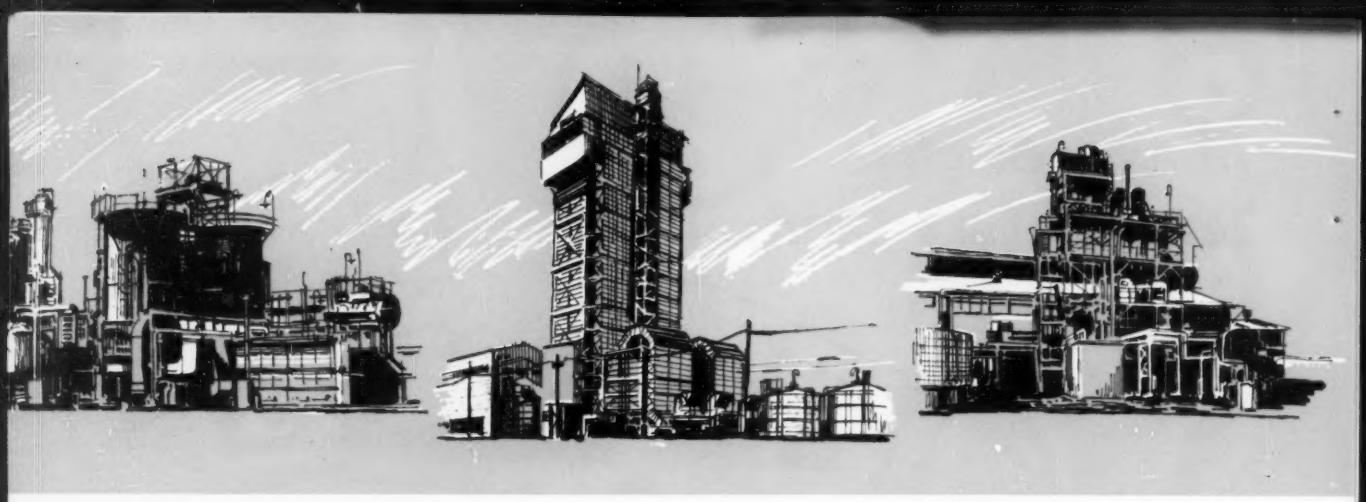

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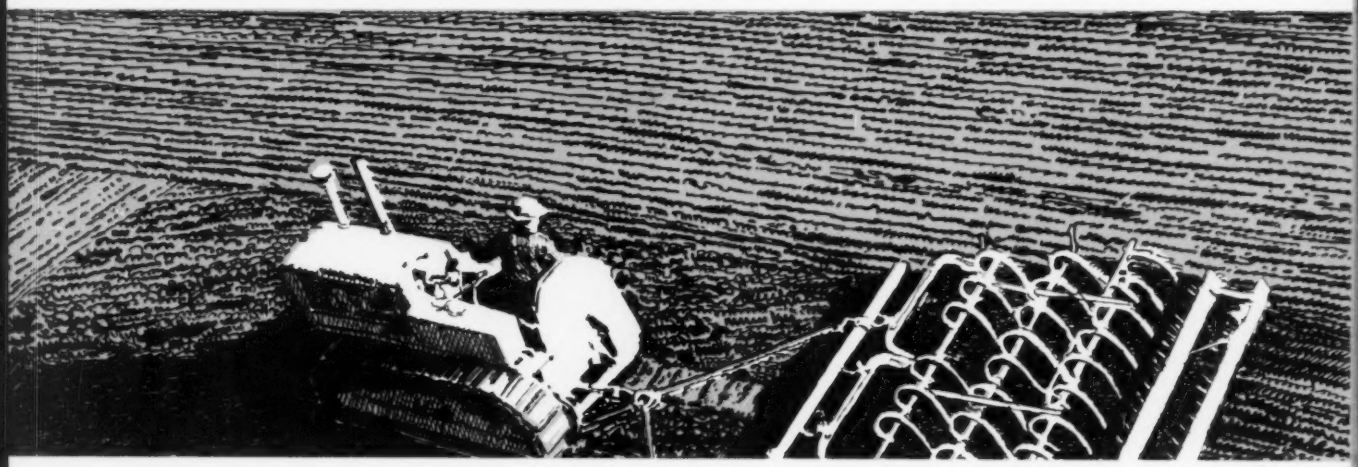
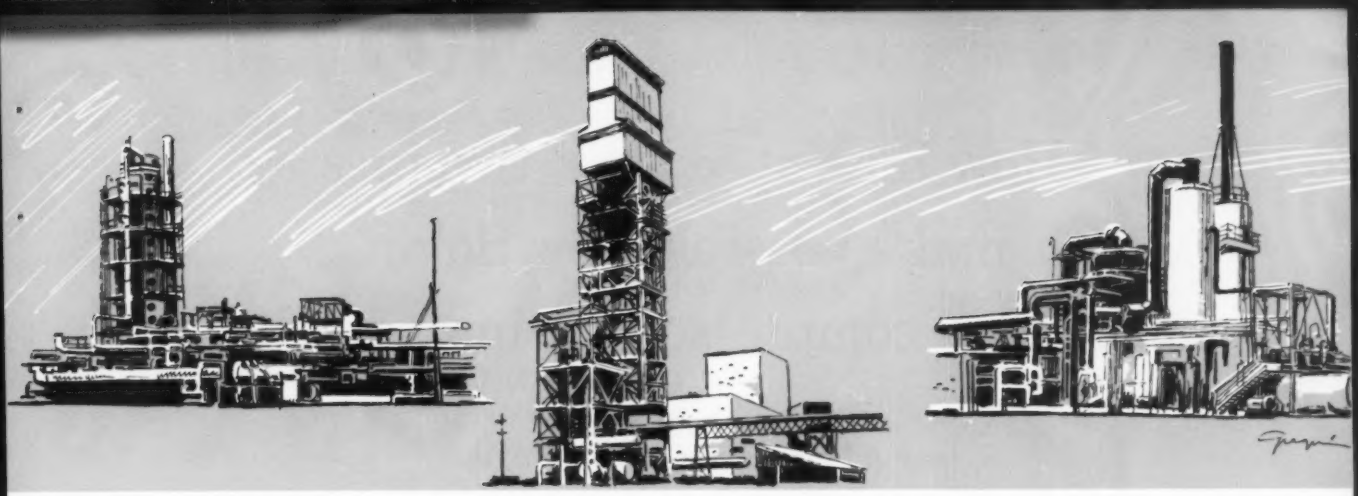
Chemico has production-proven processes for the major fertilizer chemicals



ammonia / ammonium sulfate / ammonium nitrate
ammonium phosphate / superphosphate
triple superphosphate / urea / complex fertilizers
nitric acid / sulfuric acid / phosphoric acid



In India, Pakistan and Japan; in England, France and Italy; in Hawaii, Sumatra and Formosa; in Australia, South Africa and South America; in more than half the states of the Union and in every highly populated area on earth, Chemico-designed plants are producing basic fertilizer chemicals to increase world food production.

Chemico's experience in designing plants to produce fertilizer chemicals is unmatched by any other engineering company in the world. More than 200 Chemico sulfuric acid plants are now in operation. Sixty-five Chemico ammonia plants are on stream or under construction. In January of this year, Chemico completed its thirty-fourth nitric acid plant. Other Chemico plants now in production or under construction have capacities for producing 3,700,000 tons per year of ammonium sulfate and 1,600,000 tons per year of ammonium nitrate. When the capacity of the Chemico urea plants now under construction in Pakistan and the U. S. is added to what is being produced at plants in Japan, Canada and elsewhere in the U. S., the Chemico urea process will account for more than 400,000 tons per year.

Chemico's proven processes are transformed into efficient operating plants with maximum speed and with minimum expense to the client. Ease of start-up and low operating costs are just two of the more obvious advantages of Chemico plants. If your company is considering the construction of additional production facilities, or the expansion of your present plant, Chemico will help you find the most efficient and economical solutions to your process problems.

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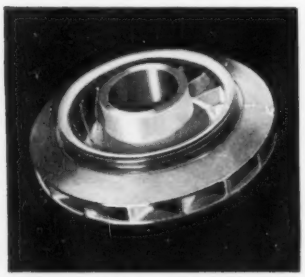
How high speed gas turbines make possible new Solar centrifugal compressor for industrial use

by Leon Wosika, chief of preliminary design
and John Glessner, project engineer
Solar Aircraft Company

The development of the high-speed industrial gas turbine is resulting in improvements in industrial equipment used in conjunction with these prime movers.

A practical centrifugal compressor for the low-volume range is one of the first of these developments.

Traditionally, reciprocating compressors have been used in the range from 500 to 1000 hp when suction pressures are from 200 to 800 psi and volume flows are 100 to 1000 cubic feet per minute at suction temperature and pressure.



It has long been known that a centrifugal compressor would be less expensive to own and operate in this range if high speed drivers were available. For example, direct drive speeds from steam turbines have been limited to 10,000 to 12,000 rpm. When gears are used to obtain high speeds, their cost and complexity has made the compressor-set look less attractive. So, in the range from 100 to 1000 suction cubic feet per minute, a low speed, conventionally designed centrifugal would have to employ compressor rotors of perhaps 15 inches in diameter, and would necessarily have very long, narrow flow passages – resulting in poor efficiency.

Now, however, the availability of industrial high speed drivers, particularly the Solar Saturn T-1000 gas turbine engine, has provided the impetus for Solar to design and build a line of efficient centrifugal compressors for the low volume range. The compressor uses compressor rotors seven inches in diameter. At approximately 20,000 rpm, wheel tip speed is only slightly over 600 feet per second, resulting in low pressure ratios per stage. High rpm and low tip speed plus careful design result in a high efficiency of 70 to 75 per cent.

High efficiency is not the only immediate advantage of Solar's compressor. When it is coupled with a gas turbine in the 500-1000 hp range, no gearbox is necessary since the turbine rotating speeds of about 20,000 rpm match those of the compressor.

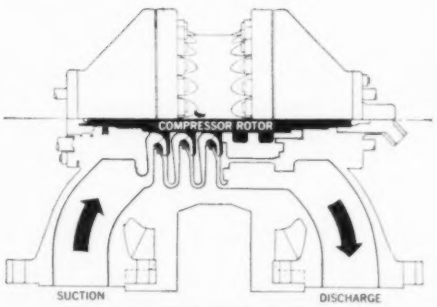
Together, the two machines make a lightweight, compact package – in the case of the Saturn T-1000 turbine, less than 7000 lbs and 300 cubic feet. This factor makes transportation and installation much easier and more economical than with the traditional compressor installation.

This portability makes central maintenance in a convenient, well-equipped shop a practical reality. In addition, the small size, light weight and absence of unbalance forces minimize foundation requirements.

A truly unique feature of the compressor is its modular design – the use of interchangeable staging to accommodate changing pressure and flow characteristics. High efficiency is maintained over the entire range of flows, 100 to 1000 suction cubic feet per minute, by use of pre-engineered, off-the-shelf compressor stages. Each stage is designed for a different flow, but is mechanically interchangeable with any other stage.

Several advantages result from modular design: (1) It reduces costs, mainly through volume production of parts and improved manufacturing methods. (2) It gives the compressor extreme service flexibility by allowing the quick change of stages in the field to accommodate new flows and pressures. (3) It allows quick delivery because all parts may be shipped directly from stock with no factory modifications necessary. (4) It tends to increase reliability and efficiency through repetitive manufacture of standardized parts.

If you wish additional data on either the compressor or the Saturn T-1000 turbine, or both, write Dept. H-165, Solar Aircraft Company, San Diego 12, Calif.



Solar Centrifugal Compressor

SOLAR
AIRCRAFT COMPANY
A subsidiary of International Harvester Company

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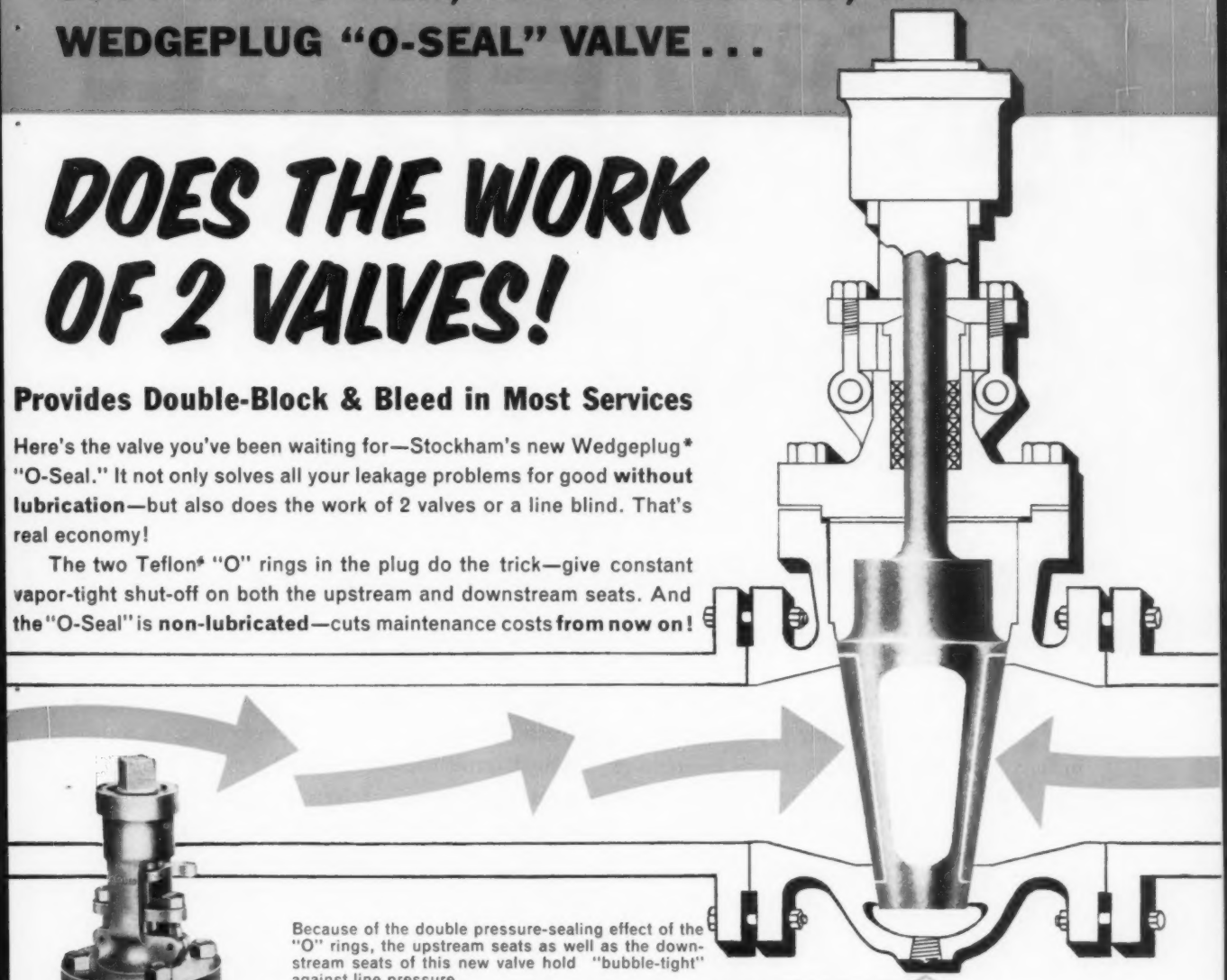
STOCKHAM'S NEW, NON-LUBRICATED, VAPOR-TIGHT WEDGEPLUG "O-SEAL" VALVE . . .

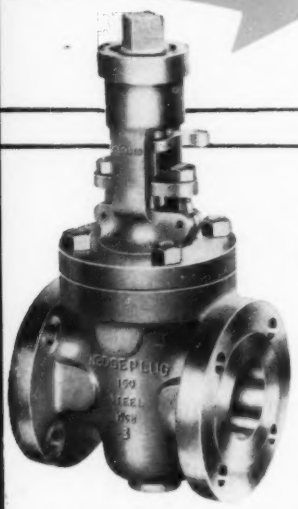
DOES THE WORK OF 2 VALVES!

Provides Double-Block & Bleed in Most Services

Here's the valve you've been waiting for—Stockham's new Wedgeplug* "O-Seal." It not only solves all your leakage problems for good **without lubrication**—but also does the work of 2 valves or a line blind. That's real economy!

The two Teflon* "O" rings in the plug do the trick—give constant vapor-tight shut-off on both the upstream and downstream seats. And the "O-Seal" is **non-lubricated**—cuts maintenance costs **from now on!**





Because of the double pressure-sealing effect of the "O" rings, the upstream seats as well as the downstream seats of this new valve hold "bubble-tight" against line pressure.

The plug in the bottom boss can be pulled to provide the **tell-tale bleed.** In extensive field and laboratory tests, this valve held bottle-tight on the upstream as well as the downstream seats when the bottom plug was removed. There is absolutely no mixing of products in manifolds.

Thus the "O-Seal" can do the job of two ordinary valves or a line blind in most services.

Your Stockham representative will advise you about the recommended services for the "O-Seal's" double-block and bleed feature.

OTHER OUTSTANDING ADVANTAGES — **Non-Lubricated — no costly maintenance necessary • Absolute shut-off that remains permanently "bubble tight" • Quick, easy operation—won't stick—ever • Double Seating for Double Safety—Ground metal-to-metal seat provides shut-off in case fire burns out "O" rings • No Product Contamination - Protected Seats.**

STOCKHAM'S NEW WEDGEPLUG "O-SEAL" VALVE

Call your STOCKHAM Distributor or Sales Representative for complete details, or write today for the new brochure on the Wedgeplug "O-Seal."

Stockham makes a *better* valve... for *every* job

WEDGEPLUG VALVE COMPANY *Division of* → **STOCKHAM VALVES *and* FITTINGS**

General Offices and Plant / 4003 North 16th Avenue, Birmingham 2, Alabama

CAST IRON—MALLEABLE PIPE FITTINGS • BRONZE, CAST IRON, DUCTILE IRON, CAST AND FORGED STEEL VALVES

KNOWLEDGE
STUDY
CREATIVE URGE
PROFESSIONAL DEDICATION

produce engineering achievement **and** accomplishment

Behind the design and manufacturing of Western Heat Exchangers lies the "creative urge" which invariably precedes productive accomplishment in any field of engineering. It is the initiative and creativity of Western's engineering personnel, combined with continuing research into the depths of thermal, mechanical and metallurgical design, that are largely responsible for the universal acceptance of Western heat transfer equipment throughout industry.

Western's engineers await your invitation to collaborate with your own engineers, toward the solution of your next heat transfer problem, however intricate.

WESTERN'S STAKE IN YOUR FUTURE

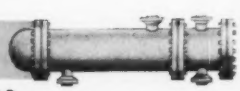
Your engineers, like ours, must *grow* in their profession, and to encourage their future development, Western is currently publishing a series of messages, as shown at right, in major trade journals. A more complete treatment of each subject is available in pamphlet form, either singly or in quantities, merely upon request. Write today.

One of a series appearing in OIL & GAS JOURNAL, CHEMICAL ENGINEERING, PETROLEUM REFINER, REFINING ENGINEER, CHEMICAL ENGINEERING PROGRESS.

serving the growth of the process industry

WESTERN

HEAT EXCHANGERS



WESTERN SUPPLY COMPANY

P.O. Box 1888 – Tulsa, Oklahoma

Personal, professional advancement demands thorough engineering knowledge, disciplined habits, creative thinking, constant application

"Intellectual let-down" — that tendency so common to many engineers to "stop learning" as soon as they acquire a sheepskin — will be completely out of style by 1999. Indeed, it is passe in today's accelerated engineering profession, because to stop learning is to stop growing:

For more data on advertised products, use Readers' Service Cards, last page.

Photographed at Standard Oil of Ohio, (Toledo Refinery)

The constant challenge and the continuous answer

The demand for ever-superior fuels from refiners is constant. The search for ever-better catalysts to help produce these fuels is continuous. At the oil companies and at Cyanamid, the searchers have found that each challenge can best be met by pooling knowledge and resources. In a word, the continuous answer lies in *cooperation*.

Cooperation with refiners helped Cyanamid develop an answer in Aerocat® micro-spheroidal synthetic catalyst. Aerocat provides high activity, stability, and selectivity through controlled physical properties. You can depend on Aerocat for efficient overall performance and satisfactory product realization.

The Cyanamid sales representative—the Man with the Golden Rule—played an important role in developing Aerocat and other catalysts. His job is not simply to sell. His job is to help you in your continuous task to meet the constant challenge. Behind his knowhow are the resources of a major catalyst producer that is also a major manufacturer of other chemicals—Cyanamid. Call when you need the aid of his skill.

Basic in catalyst chemistry

CYANAMID

AMERICAN CYANAMID COMPANY • REFINERY CHEMICALS DEPARTMENT • 30 Rockefeller Plaza, N. Y, 20, N. Y.

NOW — ORBIT'S new 6" full opening ASA 300 & 600 lb. VALVES with combination seating of TEFLON* and metal to metal.

NON-LUBRICATED for low cost maintenance and product protection.

PLUS: these additional features

- Low opening and closing torque for easy operation
- A minimum of working parts for long, trouble-free performance
- Adjustable plastic stem packing — can be added to while valve is in service and under pressure
- Positive shut-off

FOR:

Ethylene — Propane — Butane — Refinery Gases

Natural Gas — Gas Gathering Systems.

Hydrogen — Nitrogen — Ammonia.

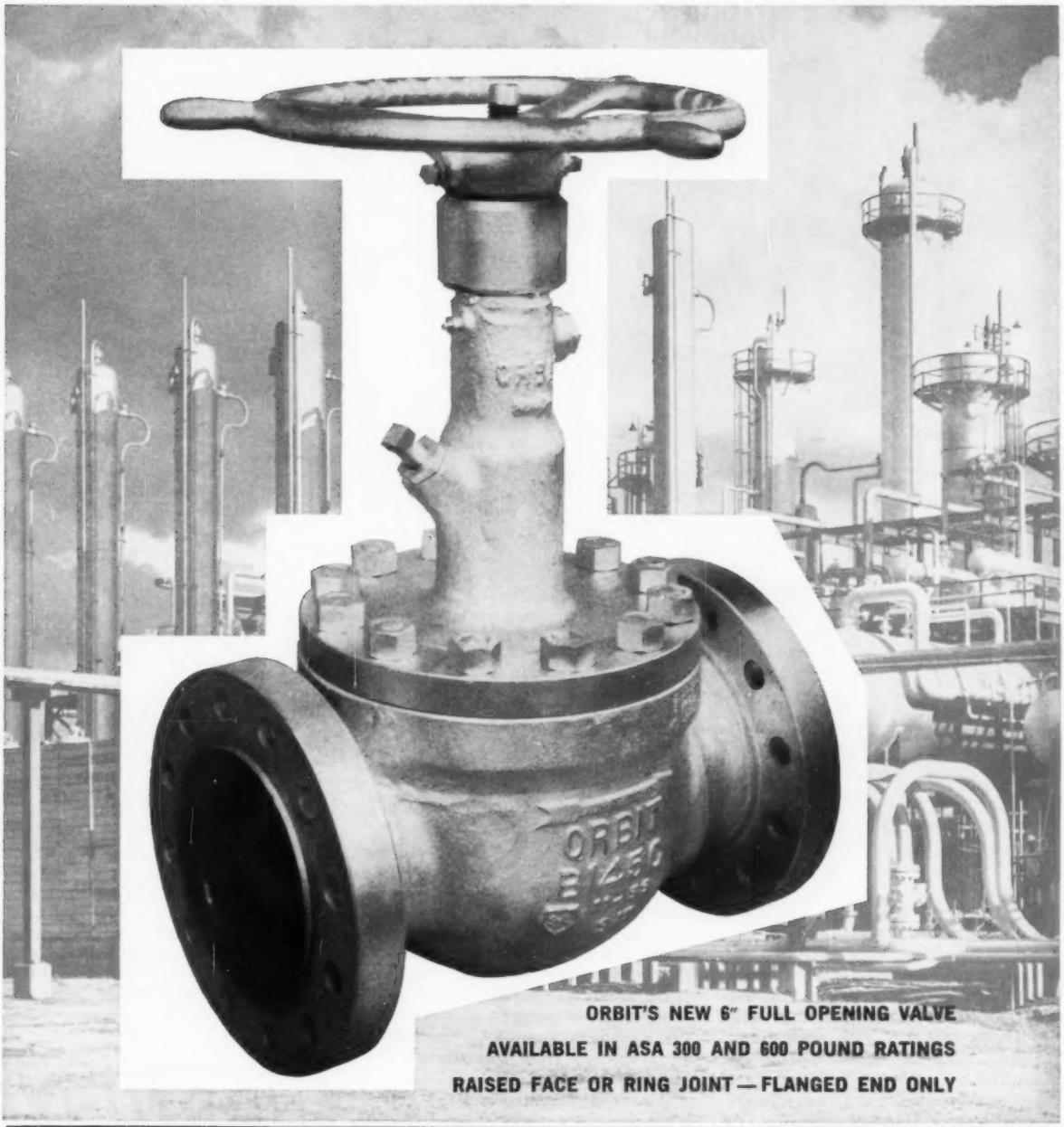
Carbon Dioxide — Industrial Gases.

*Registered Trade-Mark for du Pont's "TFE — fluorocarbon"

Write us for detailed material and dimensional specifications on these 6" Full Opening Valves which conform to ASA Standards. Flanged Ends only. Raised Face or Ring Joint.

low priced

ORBIT VALVES®

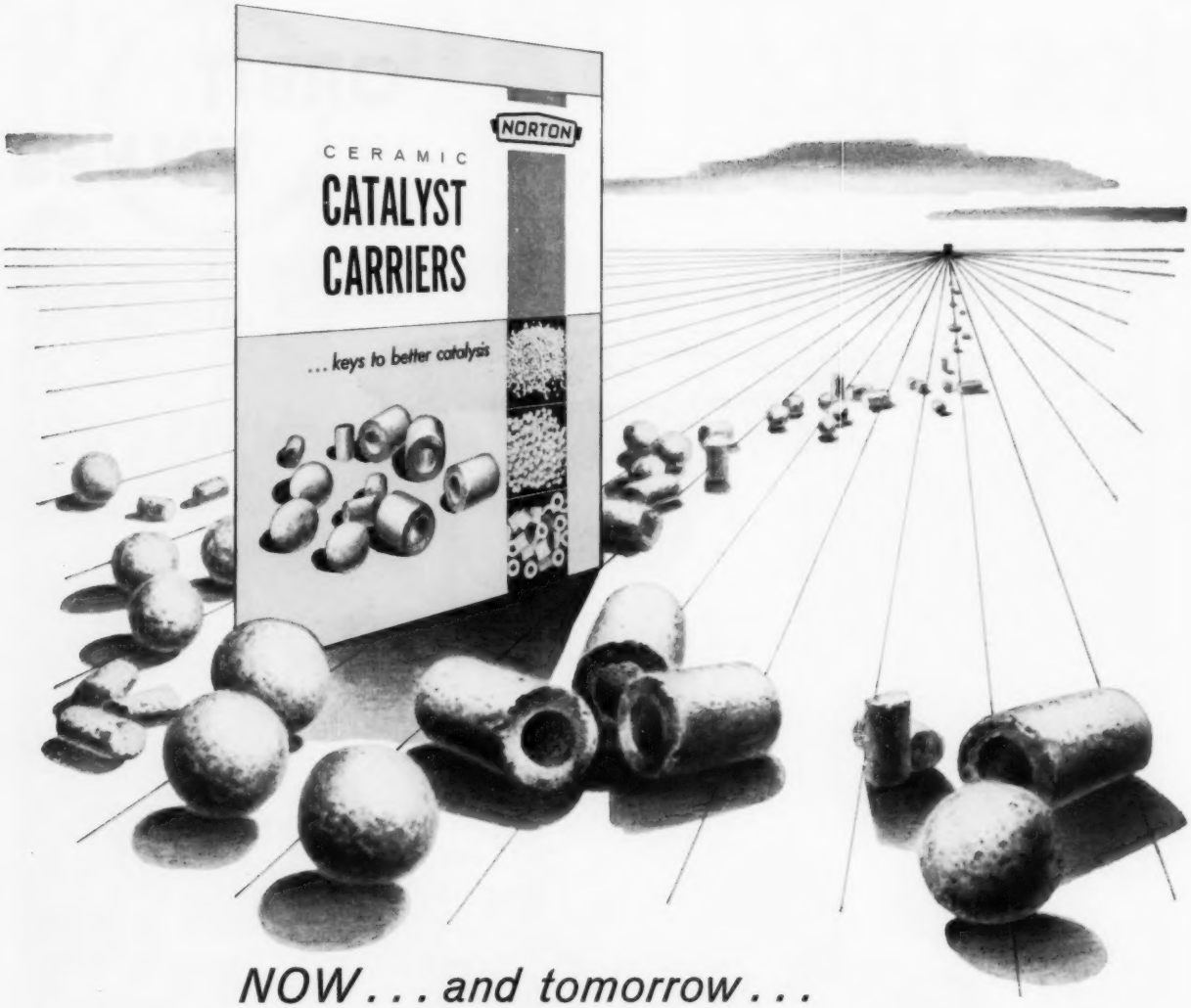


ORBIT'S NEW 6" FULL OPENING VALVE
AVAILABLE IN ASA 300 AND 600 POUND RATINGS
RAISED FACE OR RING JOINT — FLANGED END ONLY

ORBIT VALVES®

ORBIT VALVE COMPANY
P. O. BOX 699 TULSA, OKLAHOMA
PHONE LUther 4-4761 TWX TU 925

For more data on advertised products, use Readers' Service Cards, last page.



NOW . . . and tomorrow . . .

choose NORTON Ceramic Catalyst Carriers

In columns and reactors throughout the chemical and petrochemical industries, NORTON Ceramic Catalyst Carriers are helping processors to improve catalyst activity and life, lower catalyst costs, get optimum yields from reactions.

It's *consistent* high performance too, because *every* NORTON Carrier is uniform in *any* quantity from lot to lot. Size, weight, porosity, and purity are held to close tolerances. Duplication of specifications is assured.

Today, probably the most widely-used NORTON Carrier is alumina . . . in ring, sphere, and pellet form and as granules and powder. However, as new feedstocks are developed, and more demanding physical, chemical, and thermal conditions are encountered, new NORTON Carriers will be ready to meet catalysis specifications. For example, various materials are now available in experimental quantities as spheres, rings and pellets . . . in alumina, magnesia-alumina spinel, fused magnesium oxide, silica, zircon, zirconia and silicon carbide. These NORTON developments offer porosities ranging from 4% to 65%; surface areas from less than 1 to 70m^2/gram (BET method).

Also readily available is the technical assistance of the Norton Man. Through him, chemical engineers can draw upon the wealth of research and engineering data compiled over the years by the NORTON COMPANY. He is well qualified to help *you* meet catalyst carrier specifications exactly . . . efficiently . . . economically.

NORTON Carriers are described in detail in the Bulletin, "Keys to Better Catalysis". For your copy, or for technical assistance, write NORTON COMPANY, Refractories Division, 469 New Bond Street, Worcester 6, Massachusetts.

NORTON
REFRACTORIES
Engineered . . . Rx . . . Prescribed

75 years of . . . **Making better products . . . to make your products better**

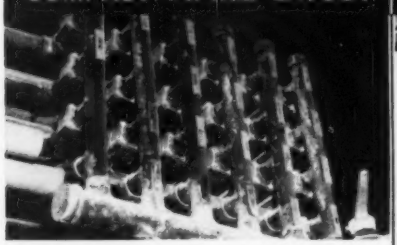
NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — **BEHR-MANNING DIVISION:** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

DESIGNED FOR MODERN PIPING!

ILLUSTRATED:
1" SIZE
SIZE RANGE:
¼" TO 6"

THE ECON-O-MISER BALL VALVE

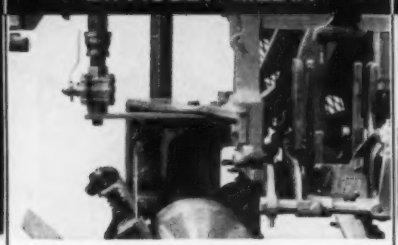
COMPACT PIPING LAYOUT



Here are 19 Econ-O-Miser Ball Valves compactly installed on this paint blending manifold. Note the absence of unions . . . this valve is both a valve and a union! The Econ-O-Miser is smaller, easier to install . . . just right for modern piping layouts, where equipment must fit into tight areas.

Let us show you . . . in your own plant! Write us about your limited space problems!

DIFFICULT MEDIA



The Econ-O-Miser Ball Valve successfully controls the flow of cold glue with a viscosity of molasses, on the WORLD Tandem Labeler manufactured by Economic Machinery Co. Clean wiping action, positive leakproof shut-off, and smooth round flow, make the Econ-O-Miser ideal for handling difficult media.

Let us show you . . . in your own plant! Write us about your media problems!

TROUBLE-FREE OPERATION

Outdoor propane and butane storage tanks in remote field processing plants require dependable positive shut-off valves on bleed lines. The unique features of the Econ-O-Miser Ball Valve provided the practical answer . . . no lubrication . . . no metal-to-metal contact . . . quick visual ON-OFF indication . . . trouble-free service.

Let us show you . . . on your outdoor applications! Write us about your valve maintenance problems!

COMPARE . . . THE ECON-O-MISER BALL VALVE

NO UNION NECESSARY

WORCESTER VALVE CO., INC.

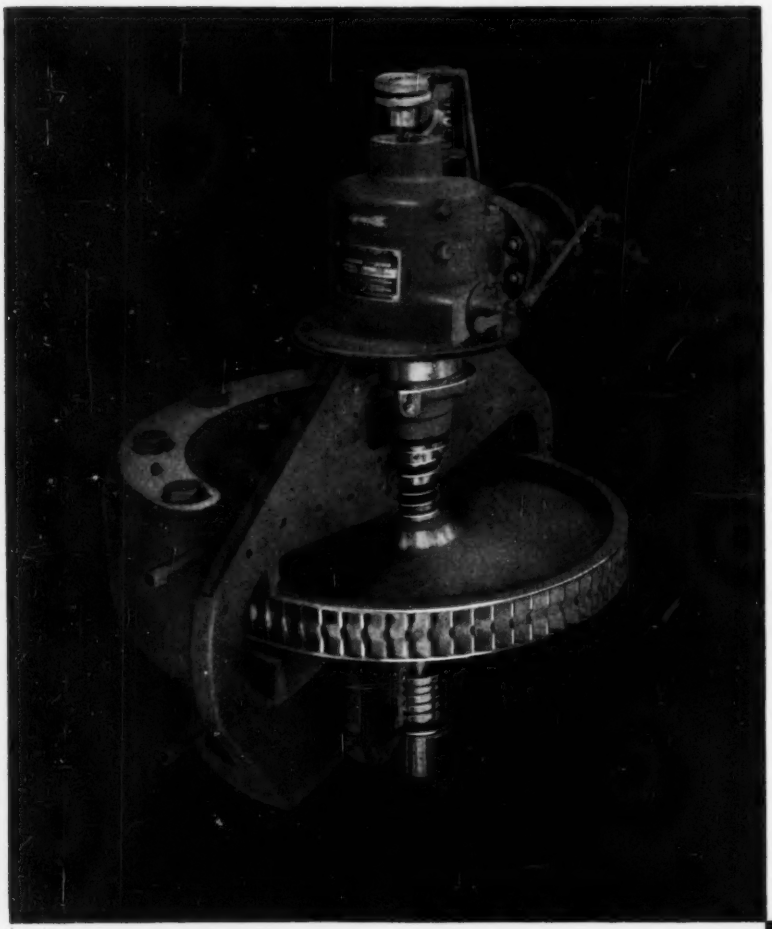
16 PARKER STREET, WORCESTER, MASS.

For more data on advertised products, use Readers' Service Cards, last page.

Here's a vertical turbine with

TERRY SOLID WHEEL

and all its advantages



When it comes to judging a turbine's ability to deliver in vertical service, ratings tell only half the story. It's the Terry construction refinements that give you assurance of long-range operational economy: Thrust bearing designed to absorb external pump thrusts ... carbon ring glands specially made for vertical operation ... casings and bearing housings split vertically for easy accessibility.

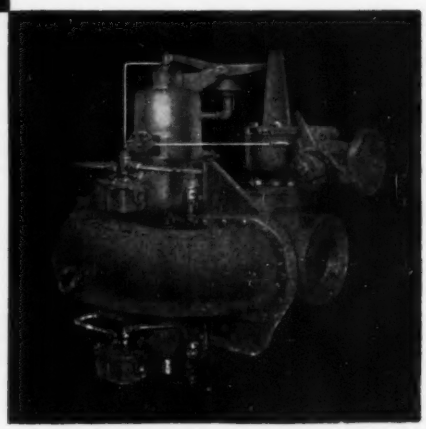
But most important, the Terry vertical turbine has an *almost* indestructible rotor. A single forging of special composition steel, it has no separate parts to loosen or work out. As the only function of the blades is to form a series of pockets, any wear which might occur would not materially affect horsepower or efficiency.

If your application demands a vertical turbine, specify Terry solid wheel. Available in capacities from 5 to 300 horsepower. And remember, the extra durability built into these vertical turbines is typical of every turbine in the complete Terry line.

For further information, send for a copy of bulletin S-137.

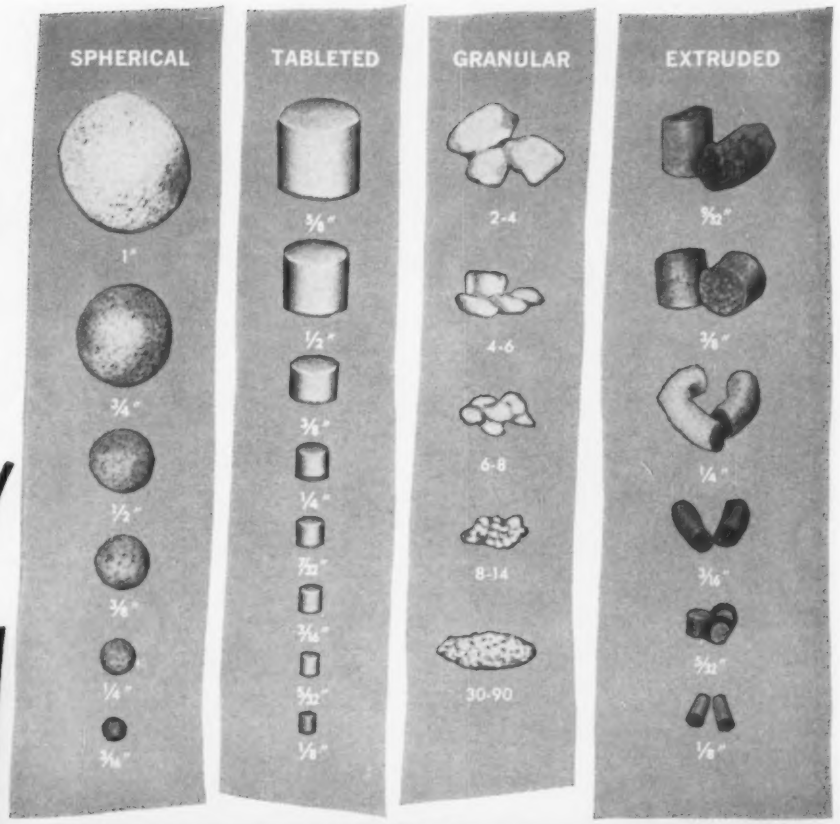
THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

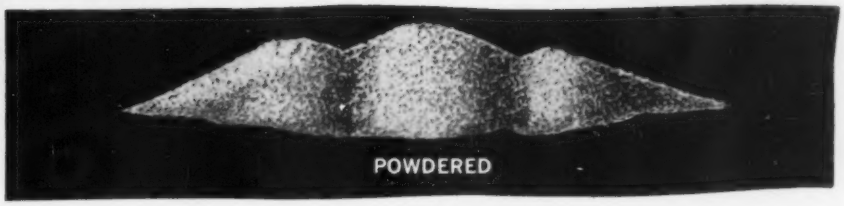
TERRY



TT-1210

HARSHAW can make the catalyst you *Specify!*





HARSHAW
has the facilities for producing carload quantities of
PREFORMED CATALYSTS
to fit special process requirements

Hydroforming	Dehydration
Cyclization	Desulphurization
Oxidation	Alkylation
Dehydrogenation	Isomerization
Hydrogenation	

Write for FREE Booklet, "HARSHAW CATALYSTS"

HARSHAW

CATALYTIC CHEMICALS SUPPLIED BY HARSHAW

Aluminum Nitrate		Cobalt Nitrate
Copper Nitrate		Manganese Nitrate Solution
Metallic Soaps (Cobalt, Manganese)		
Nickel Carbonate	Nickel Formate	Nickel Nitrate
Nickel Sulfate	Sodium Methoxide	Zinc Nitrate

Our experienced technical staff will assist you in developing the best and most economical catalyst. If you have a catalytic process in the development or production stage, a discussion with us may prove beneficial.

THE HARSHAW CHEMICAL CO.
1945 EAST 97th STREET • CLEVELAND 6, OHIO
Chicago • Cincinnati • Cleveland • Detroit • Hastings-On-Hudson
Houston • Los Angeles • Philadelphia • Pittsburgh

For more data on advertised products, use Readers' Service Cards, last page.

1800° IS NOT TOO HOT FOR NEW CALSILITE-HI

New Ruberoid Calsilite-Hi insulation for soaking heat to 1800°F. It's light, strong and so economical it can be used on all types of jobs. Calsilite-Hi is ideal for both insulation and fireproofing.

Calsilite-Hi, a molded calcium silicate insulation, extends the Ruberoid insulation line to the upper temperature limit of 1800°F. Available in half-sectional, three segmental and block form, it can be used as fireproofing for walls, partitions and ceilings as well as insulation for piping and equipment.

Calsilite-Hi is light and easy to install. It cuts and mitres quickly, smoothly and is gentle on hands. What's more, it keeps its strength even when wet, does not soften or fall off. Returns to its original thermal efficiency when dry. Resists most chemicals and alkalis in industrial concentrations.

For additional specifications or samples of Calsilite and Calsilite-Hi insulation, write: The Ruberoid Company, 500 Fifth Avenue, New York 36, New York.

THERMAL CONDUCTIVITY
(BTU/sq. ft./inch/hr./°F.)

400°F. (Mean)	0.54
600°F. (Mean)	0.64
800°F. (Mean)	0.74

Density 13.5 lbs. per cu. ft.

Compressive Strength
5% deformation (Min.) 135 lbs. psi.

Flexural Strength 75 lbs. per sq. in.

Change under Soaking Heat
24 hrs. @ 1800°F.

Loss in weight	5%
Linear Shrinkage	1.5%

The RUBEROID Co.®

Top: Foxboro Capacitance Dynalog Electronic Recorder

Below: Foxboro Octane Improvement Analyzer

The Foxboro Octane Improvement Analyzer is based on a development of the Humble Oil & Refining Company. The Foxboro Company is licensed to manufacture the analyzer under patent rights held by Esso Research and Engineering Company.

this new Foxboro system lets you measure octane improvement... continuously, automatically

Now you can have a continuous, accurate, automatic reading of octane improvement on any catalytic reformer equipped with the new Foxboro Octane Improvement Analyzer.

Here's how it works. The field-located Analyzer alternately monitors the dielectric constant of the feed stream to — and the product stream from — a catalytic reformer. Both measurements are recorded directly on a Foxboro Capacitance Dynalog* Recorder. And, since a direct correlation exists between dielectric constant difference and octane improvement, the Dynalog chart provides a continuous record of octane improvement.

The Foxboro Octane Improvement Analyzer pays for itself in as little as six months by providing data for faster recovery from reformer upsets. It also substantially reduces the number of knock-engine analyses required. Ask your Foxboro Field Engineer about this unique refining aid. Or write for Technical Information 27-111a. It has all the details. The Foxboro Company, 7410 Neponset Ave., Foxboro, Massachusetts.

*Reg. U. S. Pat. Off.

FOXBORO

REG. U. S. PAT. OFF.

For more data on advertised products, use Readers' Service Cards, last page.

KELLOGG'S WIDENING WORLD

Reduces Unit Investment and Operating Costs

Kellogg Alkylation Units Throughout The Refining World

ARGENTINA	
La Plata	1,600 BPD
AUSTRALIA	
Melbourne	2,000 BPD
Sydney	3,400 BPD*
CANADA	
Vancouver, B.C.	1,000 BPD
Calgary, Alberta	1,500 BPD
Montreal, Quebec	1,600 BPD
CHILE	
Concon	1,100 BPD
IRAN	
Abadan	6,000 BPD
SAUDI ARABIA	
Ras Tanara	1,400 BPD
UNITED STATES	
East Chicago, Ind.	2,600 BPD
Beaumont, Texas	5,000 BPD
Texas City, Texas	3,500 BPD
Whiting, Ind.	5,000 BPD
Lake Charles, La.	12,750 BPD
Lake Charles, La.	10,675 BPD

FOR REFINERS wishing to increase their barrel octane for the lowest optimum over-all expenditure, Kellogg can design and build an alkylation unit which will utilize normal refinery feeds, yield the desired quantity and quality of alkylate, yet cost less to install and operate than ever before.

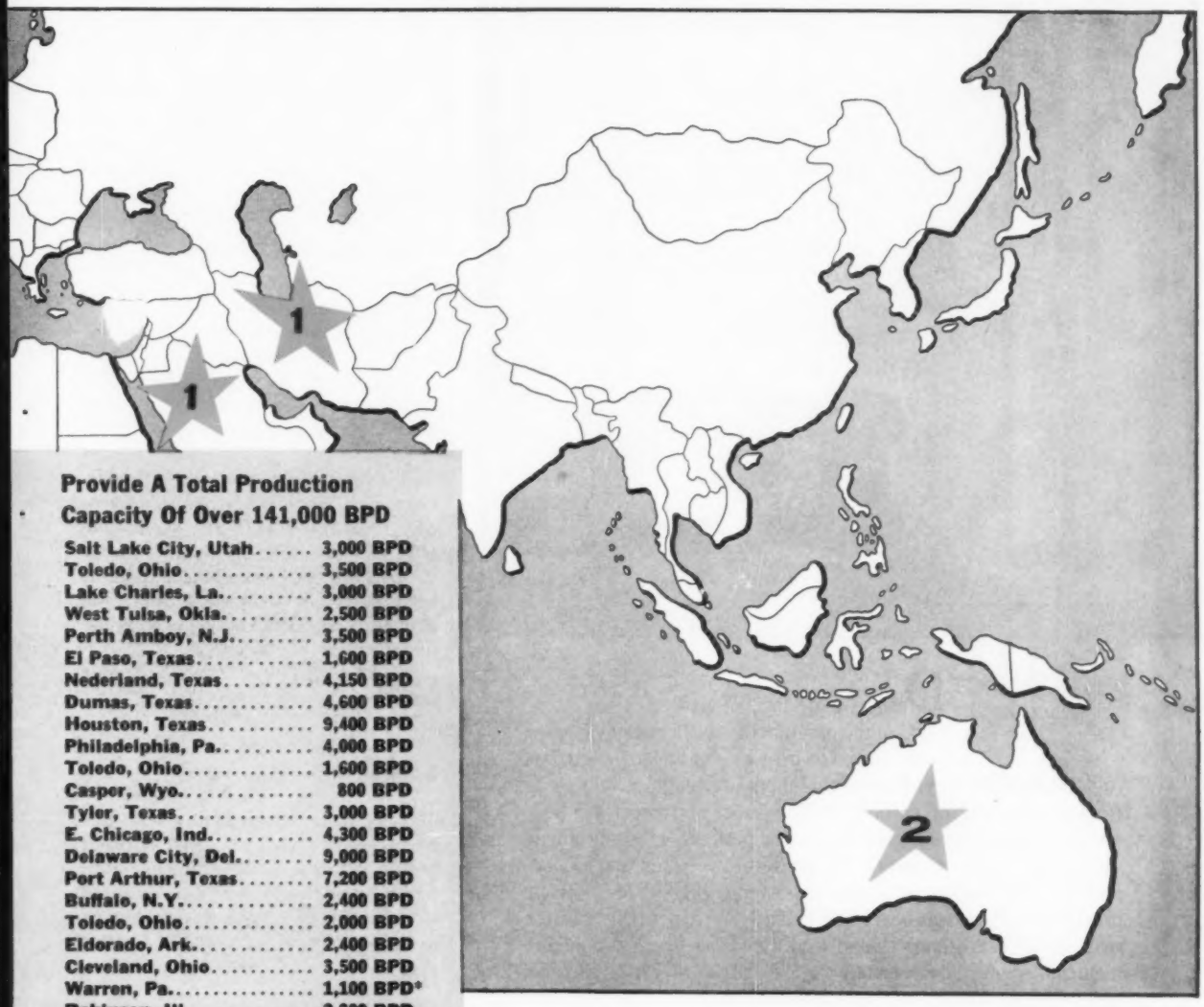
This economic approach to a high octane product for the gasoline pool, when and as required, is made possible through Kellogg's experience to date in engineering and building 38 alkylation units of various designs, for both large and small refiners, in 6 foreign countries as well as in 13 States at home.

The most efficient, most economical, and most flexible of these alkylation units are those utilizing Kellogg's most recent sulfuric acid, multi-stage cascade reactor design. Whether for 500 or 15,000 BPD, Kellogg can undertake the entire design, procurement, and construction of one of these units for a lump-sum contract.

For more data on advertised products, use Readers' Service Cards, last page.

OF ALKYLATION EXPERIENCE

—Increases Range of Feedstocks and Yields



Provide A Total Production Capacity Of Over 141,000 BPD

Salt Lake City, Utah	3,000 BPD
Toledo, Ohio	3,500 BPD
Lake Charles, La.	3,000 BPD
West Tulsa, Okla.	2,500 BPD
Perth Amboy, N.J.	3,500 BPD
El Paso, Texas	1,600 BPD
Nederland, Texas	4,150 BPD
Dumas, Texas	4,600 BPD
Houston, Texas	9,400 BPD
Philadelphia, Pa.	4,000 BPD
Toledo, Ohio	1,600 BPD
Casper, Wyo.	800 BPD
Tyler, Texas	3,000 BPD
E. Chicago, Ind.	4,300 BPD
Delaware City, Del.	9,000 BPD
Port Arthur, Texas	7,200 BPD
Buffalo, N.Y.	2,400 BPD
Toledo, Ohio	2,000 BPD
Eldorado, Ark.	2,400 BPD
Cleveland, Ohio	3,500 BPD
Warren, Pa.	1,100 BPD*
Robinson, Ill.	2,800 BPD
Toledo, Ohio	3,500 BPD

*Future

Designed to operate on butylene, propylene, amylenes, or a combination feed, these new units offer many advantages over other models. They can produce an LPG product, as well as high octane alkylate, without supplementary towers or equipment. They reduce corrosion to a minimum without extensive use of expensive chemicals. They are extremely low on acid consumption—using, for example, less than 0.3 sulfuric acid per gallon of alkylate. They are adaptable to seasonal demands—capable of maintaining peak barrel octane production at minimum operating cost.

Kellogg welcomes the opportunity to discuss the details of its alkylation process with you.

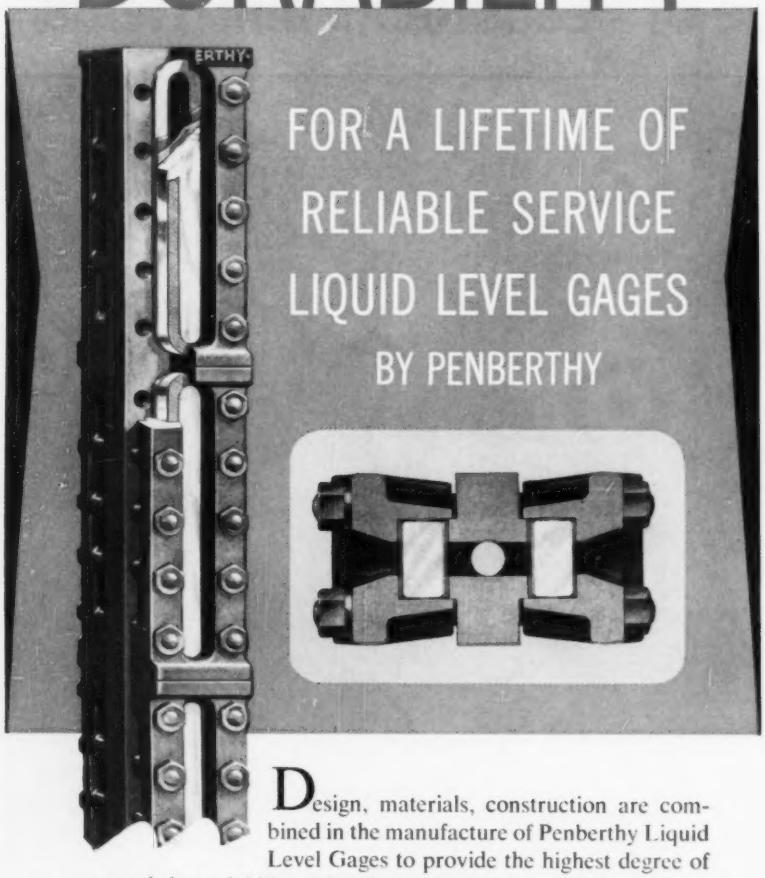
THE M. W. KELLOGG COMPANY

711 Third Ave., New York 17 *A subsidiary of Pullman Incorporated*

Offices of Kellogg subsidiary companies are in Toronto, London, Paris, Rio de Janeiro, Caracas, Buenos Aires

For more data on advertised products, use Readers' Service Cards, last page.

DURABILITY



Design, materials, construction are combined in the manufacture of Penberthy Liquid Level Gages to provide the highest degree of rugged dependability. Liquid chambers are made in one piece from a solid bar of carbon or alloy steel and precision heat treated, machined and ground . . . for perfect, leak-tight alignment and rigidity. Covers, of temperature resistant steel, completely enclose sides and ends of glass and gasket . . . for blowout prevention. Pyrex glass is used exclusively . . . for its greater strength and resistance to shock and erosion. Even the gasket material is specially selected . . . for its high resiliency and ability to withstand excessive compression. In brief . . . For *lasting* accuracy in a liquid level gage, look to Penberthy.

PENBERTHY MANUFACTURING COMPANY
Division of Buffalo-Eclipse Corporation
PROPHETSTOWN, ILLINOIS
SALES OFFICE: 2660 E. GRAND BLVD., DETROIT 11, MICH.

PENBERTHY
Dedicated to Quality Since 1886

GENTLEMEN: Want complete details on your liquid level gages. Please send Catalog #36 immediately.

NAME_____ TITLE_____
COMPANY_____
ADDRESS_____
CITY_____ ZONE_____ STATE_____

The Mail Box . . .

Word Is "Through"

A typing error crept into the Industry Quiz for September, 1960 page 20. The answer to Question 14, instead of "(a) and (e)," should have been "(a) *through* (e) are essential." Data on pump volume, total dynamic head, horsepower, material of construction and special seals should be passed on to the estimating department. Coupling type and motor manufacture are available in company standards.

Seen in Germany

To The Editor:

Your two articles entitled "Corrosion Measurement Short Course" and "New Charts Speed Drum Sizing" published on pages 148 and 170, July PETROLEUM REFINER were very interesting and informative.

However, we wish to place a question, which is quite a riddle: Is Mr. Ostrofsky Mr. Kerns or is Mr. Kerns Mr. Ostrofsky? Is it the same man with two different names or do they happen to be twins, whose parents became legally divorced between the first and second delivery? Who is the first born?

With much interest we await your worthy explanation.

E. T. Lee
Bauleitung Esso Raffinerie
Koln-Merkenich, Germany

Editor's Note—Even before Mr. Lee had seen his July issue, a lot of other people, including our editorial staff, had spotted this mixup, which caused us to use on this page in our August issue a picture of the real Mr. Ostrofsky.

Wanted:

YOUR Ideas . . .

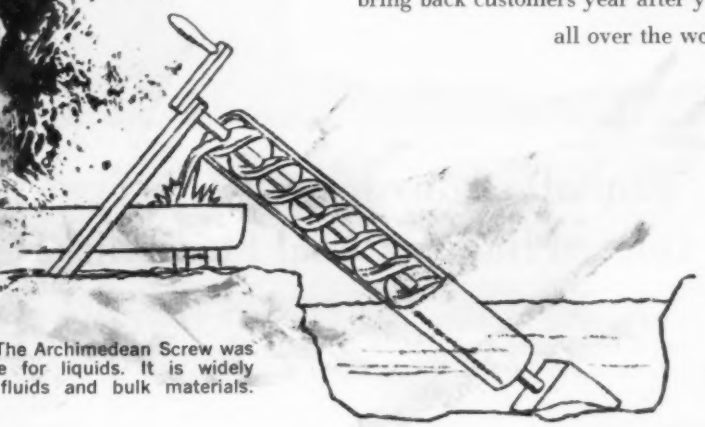
The Editors of
PETROLEUM REFINER
invite letters from readers
discussing timely topics
pertinent to the
industry

For more data on advertised products, use Readers' Service Cards, last page.

THE QUALITY OF THINKING

Archimedes, the ancient Greek philosopher, developed principles of mathematics and mechanics which unlocked secrets leading to the development of some of our most modern processes. His mind was at home in the farthest reaches of the abstract, at work in the closest confines of the practical.

At Brown & Root — whether it is one mind, or a group of minds — thinking knows no boundaries for inspiration. Problems in engineering and construction are solved in ways that consistently save our clients time and money. Brown & Root places a premium on the quality of thought, combined with thoroughly-seasoned knowledge and experience. The results bring back customers year after year, all over the world.



Over two thousand years ago, The Archimedean Screw was introduced as a lifting device for liquids. It is widely used today in moving both fluids and bulk materials.

BROWN & ROOT, INC.

Engineers · Constructors • POST OFFICE BOX 3, HOUSTON 1, TEXAS • CABLE ADDRESS-BROWNBILT

NEW YORK • WASHINGTON • LONDON • EDMONTON • MONTREAL • SÃO PAULO

For more data on advertised products, use Readers' Service Cards, last page.

SCIENTIFIC DESIGN'S PROCESS SKILLS continue to make news

Here are some recent technical developments reported in the press

PETRO-TEX TO BUILD WORLD'S LARGEST MALEIC ANHYDRIDE PLANT

May 24—Scientific Design Company will design a 30,000,000 pound per year maleic anhydride plant using a new Petro-Tex process employing butene feedstocks and certain phases of SD's own process.

GOODYEAR TIRE AND RUBBER COMPANY TO PRODUCE 2 NEW SYNTHETIC RUBBERS

May 17—Scientific Design Company will design and engineer new polyisoprene and polybutadiene plants in Beaumont, Texas.

Phthalic Anhydride Producers Offered Raw Material Flexibility

June 6—Scientific Design Company announced a new catalyst which for the first time permits the use of ortho-xylene, naphthalene or any mixtures of both as raw materials.

SD-SW PROCESS MAKES SEA WATER FRESH

May 24—Scientific Design Company and Struthers Wells Corporation have successfully tested a new freezing process to produce fresh water. The process represents a major breakthrough in the production of large ice crystals through the controlled crystallization of sea water.

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HOW TO BLEND FOR VOLATILITY

George H. Unzelman and Eugene J. Forster
Ethyl Corporation, New York

IMPROPER PERFORMANCE of an auto engine due to fuel volatility can be related to results from certain laboratory tests of the engine's fuel. The most commonly used tests are vapor pressure and distillation.

This report will discuss factors of vehicle, weather and fuel which affect volatility requirements and then suggest fuel specification ranges which will give the most satisfactory engine performance.

The particular boiling-ranges of fuels which are important in controlling various volatility problems are summarized in Figure 1. Where front-end volatility is important vapor pressure can be an alternate or additional factor for control.

Some volatility problems are seasonal in nature. Others exist regardless of the weather although they can be aggrevated by prevailing atmospheric and driving conditions. Furthermore, compromises are needed in order to consider several engine problems at one time.

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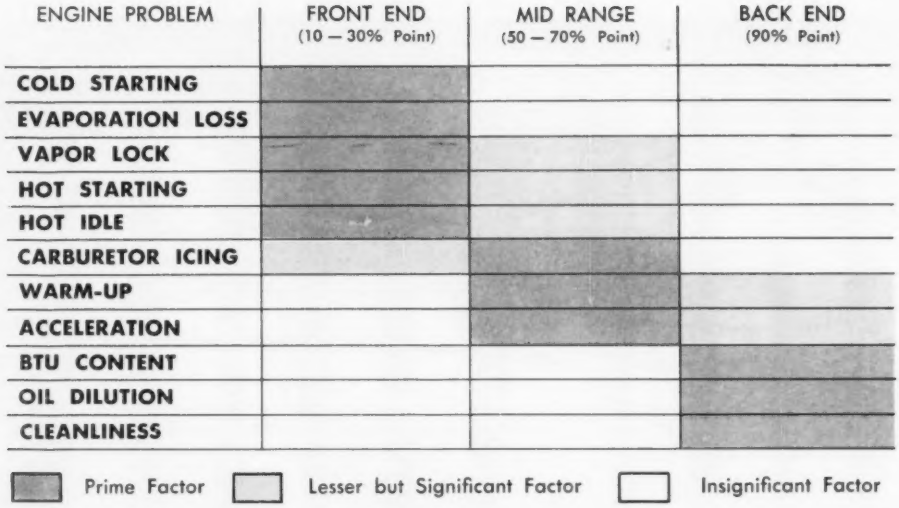


FIGURE 1—Each engine problem due to fuel volatility can be related to a certain portion of the fuel's boiling-range.

In any case, the refiner usually handles his volatility problems on a seasonal basis. Thus associated car problems will be discussed on the following bases:

Hot Weather Problems
- Vapor Lock
- Hot Starting
- Hot Idle

Cold Weather Problems
- Cold Starting
- Warm Up
- Carburetor Icing

Non-Seasonal (Year Around) Problems
- Acceleration
- Fuel Economy and Evaporation Losses
- Crankcase Oil Dilution
- Engine Cleanliness
- Octane Maldistribution

Hot Weather Problems

The performance problems occurring during hot or unseasonably warm weather result from vapor formation in a vehicle's fuel induction system. Vapor lock, of course, is the most important hot weather problem and depends upon the rate of vaporization of motor fuel at various temperatures and pressures. Experience has indicated that both hot starting and hot idle are somewhat less critical.

In a CRC study,[28] the incidence of hot starting difficulty, hot stalling and vapor lock was investigated at such likely trouble-spots as traffic lights, toll gates, turnpike parking lots, etc. The most severe problems occurred after cars were parked and allowed to "heat soak" following high-speed driving. In one case (ambient temperature = 105-110° F), 25 percent of the cars tested showed some type of malfunction due to vapor lock. Fewer problems were encountered in city traffic. The information in Table 1 was presented by Wilson, et al.[105] based upon interviews in connection with a vapor lock survey.

Vapor handling has become a more serious problem in recent years because of the increasing difficulty of rejecting heat from under the hood. Variations in vapor lock incidence weighted with model year up to 1952, are shown in Figure 2.[105]

Cars built in the later years were generally worse than their predecessors. The large variation in a single car (Make C) over the years is also shown. Improved fuel pumps and fuel systems have tended to make modern cars less critical toward volatile fuels. At the same time, recent trends toward increased horsepower, engine size and number of power accessories have resulted in a general rise in under-the-hood temperatures.[18]

Modern automobile design with lower hood lines has diminished engine compartment space and this adds to

TABLE 1—Frequency of Vapor Lock[105]

	Percent Drivers Having Vapor Lock		
	Never	Occasionally	Frequently
Level Road	52.6	31.8	15.6
Mountain Grades	62.9	32.0	5.1

the problem of suitable heat rejection. Vapor handling problems may be temporarily relieved by the advent of the U. S. compact car, with its smaller engine and fewer power accessories. Although the compact cars respond to volatility the same as conventional cars in regard to cold starting and warm-up operation, they have a lower fuel demand on acceleration which makes them less critical of vapor lock.[82] However, the crowded engine compartment may again be a factor as the trend toward "compactness" continues. There also is strong evidence a mild horsepower among compact cars has begun.

Cars equipped with air conditioners experience higher than average underhood temperatures. Rises as high as 54° F above ambient temperature have been recorded.[47] This, of course, reduces the vapor tolerance of air conditioned vehicles because of higher fuel temperatures. Tests have shown the resulting volatility tolerance of a group of cars can average 1.3 Rvp lower than before installation of the air conditioner.[58,65]

Driving conditions also can have considerable effect on volatility tolerance. In mountainous areas, the slower driving speeds and high engine loadings required to navigate steep grades result in higher underhood temperatures than experienced on level roads. The effects of mountainous driving on vapor lock tolerance has been described in a recent study.[62]

The terminology used by the refining and automotive industries to describe various car malfunctions due to high volatility has not been consistent over the years. For example, one car manufacturer refers to all hot fuel handling problems as some form of vapor lock. Hot weather problems are defined as: "Any disturbance of liquid flow in the fuel system caused by formation of fuel vapor. This includes leaning or richening of mixture ratio as evidenced by any of the following: Loss in power, momentary cutout, complete engine stoppage, poor idling, stalling in city traffic, or poor hot starts."[12]

In this discussion, vapor lock, hot starting, and hot idle are treated individually as parts of the over-all problem of vapor handling.

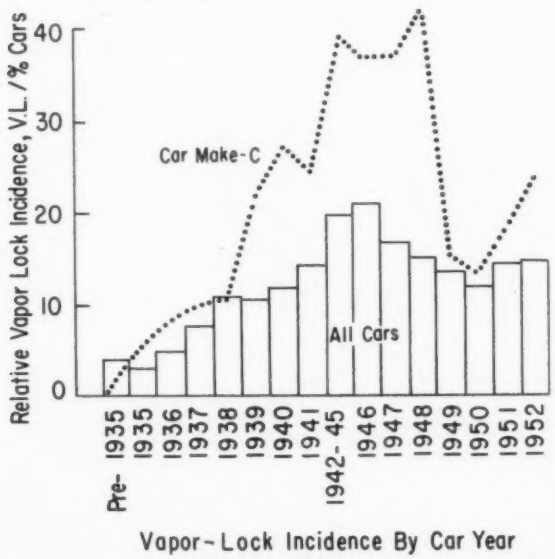


FIGURE 2—Cars built in the later years were generally worse about vapor locking than their predecsssors.

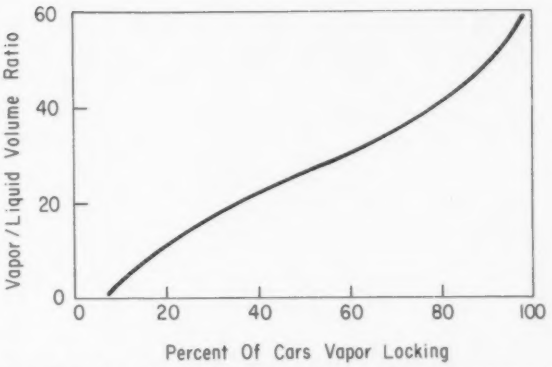


FIGURE 3—The limiting vapor-liquid ratio was averaged for 109 cars on the basis of 1948-1952 new car registration.

VAPOR LOCK

Vapor lock is defined as the inability of the fuel pump to supply sufficient liquid fuel to the carburetor float bowl because of vapor formation in the fuel system. This takes place when the vapor-forming tendency of a gasoline exceeds the capacity of the fuel system to handle vapor under the operating conditions of the vehicle.

Vapor bubbles may form anywhere in the system from the gas tank to the carburetor. When this occurs, the pressure differential causing gasoline to flow through the fuel pump to the carburetor is destroyed by vapor. The result is partial or complete stoppage of fuel flow. Normal operation is interrupted because of a leaning of the air-fuel mixture. The result may be poor idle, loss in acceleration, reduced power at high speeds, knocking due to lean mixtures, and even complete engine stoppage. In heavy duty operation of trucks and buses, lean mixtures also may shorten exhaust valve and piston life.

Vapor lock is affected by any of the following:

- Fuel demand of the engine
- Ability of the fuel system to handle vapor
- Temperature and pressure of the gasoline in the system
- Volatility characteristics of the gasoline.

Fuel demand and vapor capacity are functions of car design and operating conditions. The fuel is subjected to temperatures and pressures controlled by car design, operation and prevailing ambient conditions. The amount of vapor formed under any condition depends on fuel volatility.

Fuel Characteristics. The rates of vapor formation at various temperatures and pressures determine the relative vapor locking tendencies of gasoline. Surveys have been conducted intermittently in the past to correlate fuel properties with the incidence of vapor lock. Results of one such survey, relating the vapor/liquid volume ratio for vapor lock to percent of cars tested, are shown in Figure 3.[47]

The vapor/liquid (V/L) ratio is defined as the volume of vapor formed, at a given temperature and pressure, per unit volume of liquid fuel. If some ratio is exceeded, vapor lock will occur. Atmospheric temperature and pressure affect vapor lock by governing whether a fuel will exceed the V/L limit. At a given barometric pressure, the V/L ratio of a gasoline will depend only on

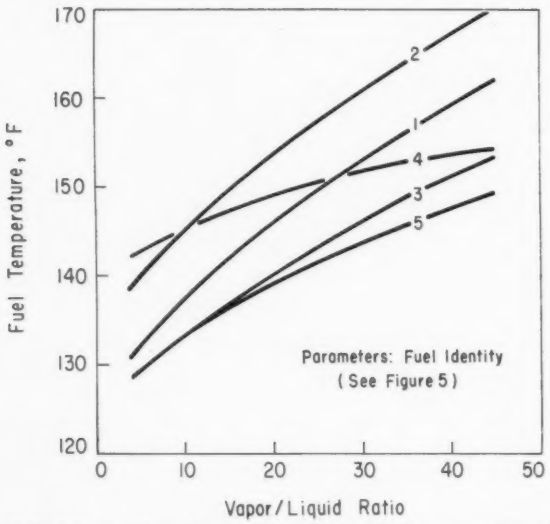


FIGURE 4—The shape and position of the vapor/liquid ratio curve depends upon the volatility characteristics of the fuel.

its temperature. This temperature-V/L relationship, then, directly relates a fuel's volatility to its vapor lock performance in a vehicle in terms of existing ambient temperatures.

The vapor/liquid ratio of a fuel may be measured in the laboratory. There are currently two test methods available for determining the vapor forming characteristics of gasolines—the CRC and the Sunbury procedures which are discussed in an accompanying box. Both give similar results and can measure the V/L ratio of a fuel at various temperatures for constant pressure.

The Temperature—V/L Relationship. When the V/L ratios of fuels at various temperatures are plotted, curves similar to Figure 4 are obtained. The shape and position of the curve depends upon the volatility characteristics of the fuel.

The temperature-V/L relationship can be used to show the effects of individual fuel properties on vapor forming characteristics. Consider, for example, the temperature-V/L curves (Figure 4) of the five fuels represented in Figure 5. The fuels are typical premium or regular samples marketed during the summer of 1959 and were selected to illustrate the effects various volatility properties can have on vapor forming characteristics. Some of the more significant observations are as follows:

- Fuels 1 and 5: Have the same Rvp but different distillation curves. Fuel 1, with a relatively steep V/L curve, represents a fuel containing only a small amount of butane while Fuel 5 contains a higher percentage. As a result, the rate of vapor formation of 5 is greater than 1 since more vapor is formed per degree rise in temperature.
- Fuels 4 and 5: Have essentially the same distillation curve but different Rvp's. The difference of 1.7 psi in Rvp has a marked effect on the V/L curve, particularly at lower V/L values.
- Fuels 1 and 2: Represent fuels with the same 50 percent point but different front-end volatilities and Rvp's. The V/L curves of these particular fuels have the same slope but represent different levels of volatility.
- Fuels 3 and 5: Represent fuels with the same Rvp and front-end volatility but different 50 percent points. The V/L curves of these fuels are the same at low V/L ratios, but diverge as V/L ratio increases.

The foregoing comparisons also stress the fact that no one volatility property is capable of reliably predicting the vapor forming tendencies of fuels. It should be pointed out that the fuels discussed are typical and no attempt was made to select extremes. Therefore, the variation in the temperature-V/L relationship between commercial fuels is often greater than illustrated.

It is difficult to assign a definite V/L tolerance to the vehicle population because of wide differences in fuel systems among various makes and models of cars. The extremes are shown by the V/L ratio requirement curve for a particular survey in Figure 3. In this case, the limiting ratio varied from almost 0 to a value of 50 or more. However, road test data from various sources over the years has indicated that the average vehicle has a limiting V/L ratio of somewhere between 15 and 25.[47] From a review of these data, an arbitrary V/L ratio in the range of 20-25 is considered practical when designing fuel to meet the vapor lock limits of current passenger cars.

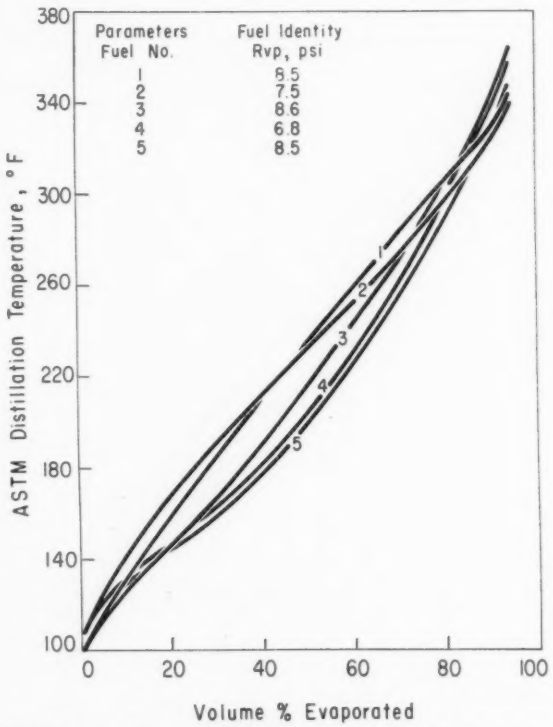


FIGURE 5—No one volatility property is capable of reliably predicting the vapor tendencies of fuels.

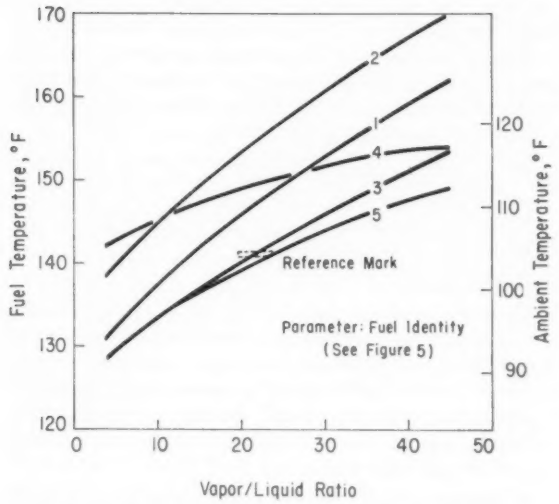


FIGURE 6—Fuel 3 represents maximum volatility and maximum desirable use of light hydrocarbons.

Many factors affect the V/L tolerance, such as, the severity of test condition, age and condition of fuel system components and variation of individual cars from the average. For example, a vehicle population composed of older models would tend to be more critical of vapor-formation than a population comprised mainly of recent-models. Trucks have higher fuel requirements than passenger cars and can tolerate less vapor formation before a deficiency in fuel occurs. This is true even though trucks are equipped with the most modern automotive fuel pumps. For these reasons, the limiting V/L ratio for regular gasoline is somewhat lower than for premium fuel. Generally, a ratio of 15-20 for regular will give the same degree of vapor-lock protection as 20-25 for premium.

Practical use of the temperature-V/L concept is illustrated in Figure 6. A reference mark indicates that a V/L ratio in the range of 20-25 at an ambient temperature of 105° F has been selected as a limiting condition. Fuel 3, having a curve which passes through the reference mark, represents maximum volatility and maximum desirable use of light hydrocarbons. Curves of fuels 1, 2 and 4 lie above the mark and represent a more conservative approach. Gasolines whose curves fall below the mark, such as Fuel 5, would be subject to vapor lock.

The type of light hydrocarbon used for volatility adjustment is extremely important from a vapor lock standpoint. Greater care must be taken in the control of a fuel pressurized with pentane or natural gasoline than for one adjusted with butane because more severe vapor locking difficulties may result during unseasonably hot weather. The reason for this is simply that about 3 times as much pentane can be blended as butane to achieve the same finished vapor pressure. Vapor formation proceeds at a very rapid rate in fuels pressurized with large quantities of less-volatile pentane once designed-for fuel temperatures are exceeded.

Laboratory measurement of the temperature-vapor/liquid relationship is involved and time-consuming. An empirical method for calculating the V/L curve has been derived, based on many measurements made with the CRC apparatus. The method is described in the 1946 CRC Handbook[21] and utilizes the Rvp of a fuel, together with the 10, 20 and 50 percent evaporated points to calculate temperatures required to reach various V/L ratios. The calculation is simplified if a fuel variable such as distillation slope, is assumed constant. This treatment of the V/L procedure is so described by Kersten and Caputo.[52]

Weather. The atmospheric conditions which influence the incidence of vapor lock are temperature, barometric pressure and wind velocity. Air temperature and wind velocity and direction affect under-the-hood temperatures. The effects of wind velocity on the characteristics of gasoline required for incipient vapor lock have been given by Domke, et al.[25] Barometric pressure determines the absolute pressure existing in a vehicle's fuel system.

Ambient conditions in a given marketing area determine the control temperature. Some refiners design for the hottest weather encountered (i.e., the highest on record for any season or month). Others use some lower level. For example, experience has shown that an ambient temperature not exceeded on more than 5 percent of the days in a given locale is appropriate to establish volatility limits.[47] The exact temperature chosen will depend upon the degree of protection desired by the refiner.

Necessary temperature records for a marketing territory are available from the U.S. Weather Bureau station in that area. Statistical weather data are available for over 250 localities throughout the United States.

The critical temperature that affects vapor lock is at the inlet of the fuel pump. Fuel pump inlet temperatures average about 37° F above ambient air temperatures, a value widely accepted for vapor lock studies.[8, 47]

The altitude of the marketing area must also be considered in fuel design. The average V/L range of 15 to 25 applies to sea level conditions. Because of the lower barometric pressure, a 1,000-foot increase in altitude lowers the limiting temperature for vapor lock approximately 2½° F. In practice, reduced pressure tends to be offset by decreasing ambient temperatures (about 3° F per 1,000 ft.) so that the two effects generally cancel each other.

Isovapor-Lock Concept. A number of expressions of volatility have been proposed which relate Rvp and distillation to vapor lock. For example, the isovapor-lock concept developed by Phillips Petroleum Company utilizes Rvp and a characteristic of the front-end of the distillation curve as parameters to define vapor locking tendencies in vehicles. An example curve is shown in Figure 7 for fuels 1 and 4 discussed before, where Rvp has been plotted as a function of the 10 percent point slope. (Fuels more volatile than shown, with regard to either Rvp or distillation, would be expected to cause vapor lock in this car when the fuel temperature exceeds 151° F. A family of such curves may be derived to cover a range in temperatures).

The two fuels have the same V/L ratio of 27 at a fuel temperature of 151° F. All fuels having volatilities corresponding to points on the isovapor-lock curve have equal vapor locking tendencies under the given set of conditions. At a fuel temperature of 151° F, fuels repre-

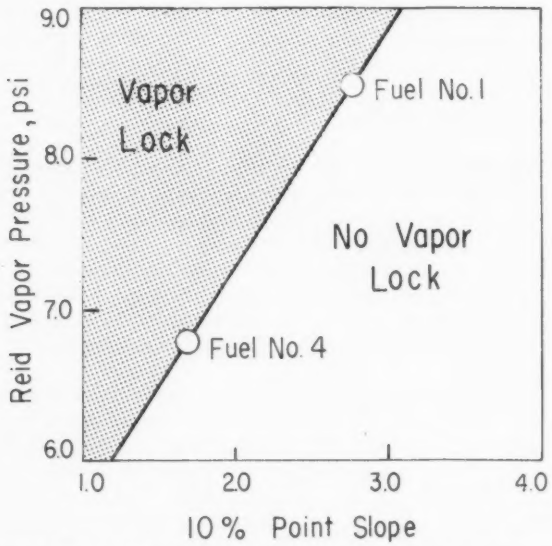


FIGURE 7—The isovapor-lock concept utilizes Rvp and a characteristic of the front-end of the distillation curve. (See Figure 5 for fuel identity.)

sented by the isovapor-lock curve will attain the same vapor-liquid ratio under the same barometric pressure.

An isovapor-lock curve can represent the limiting V/L ratio for a specific car or car population. The curve may be established for fuels by actual road tests without any consideration of V/L properties. Or, it may be drawn based on critical V/L ratios. In either case, the isovapor-lock curve represents fuels having the same vapor-locking tendencies—generally the curve is developed for incipient, or borderline, vapor lock.

The convenience of the isovapor-lock method lies in the fact that V/L tolerance is related in direct, graphical form to the fuel qualities controlled in blending —Rvp and distillation. In practice, one of these properties is seldom changed without a corresponding change in the other. Thus, the isovapor-lock chart is a convenient way of viewing the effects of changes in volatility.

In practice, test fuels representing a minimum of at least two different Rvp-distillation relationships are rated in a car to define vapor locking limits. In this case, the vehicle itself is the V/L test apparatus used to determine the vaporizing characteristics of fuels under given temperature and pressure conditions. The procedure requires that all data be compared at the same ambient reference conditions. Volatility limits are adjusted to standard reference conditions of 100°F and sea level barometric pressure. Suitable correlations have been developed to accomplish this.[36]

The technique can also be used to evaluate the fuel system and its component parts.[36] Some of the many fuel variables used as a measure of the front-end distillation characteristics are:

- 10 percent evaporated slope[36]
- 30 percent evaporated temperature[37]
- 10 and 50 percent evaporated temperatures[47]
- percent evaporated at 140° F[8]
- percent evaporated at 158° F[24]

All agree that the point or points used should define the shape of the front-end of the distillation curve for a wide range of gasolines. It is apparent, however, that there is a difference of opinion about which points are most accurate. Inconsistencies in the isovapor-lock method have been found by Bernard, et al.[8] from a survey of published data.

A nomograph based on the isovapor-lock concept has been developed by Phillips Petroleum Company which relates Rvp and 10 percent evaporated slope with ambient temperature and altitude to yield an R_v number which represents vapor locking tendency.[53,55] The R_v value is equivalent to the Rvp of a hypothetical fuel having a 10-percent point slope of 2.0 marketed at sea level and 100° F ambient temperature and having the same vapor locking tendencies as the given fuel marketed under its own ambient conditions.

The nomograph is based on continuous surveys of motor fuel volatility conducted and published by Ethyl Corporation. The rating system would minimize the need for road vapor lock tests through study of the average characteristics of fuels sold day-by-day throughout the country. The assumption is made that fuels which are marketed successfully over a period of years have volatility characteristics posing no problems with regard to vapor lock. The correlation is shown in Figure 8.

A R_v value of 11 or below is suggested as conserva-

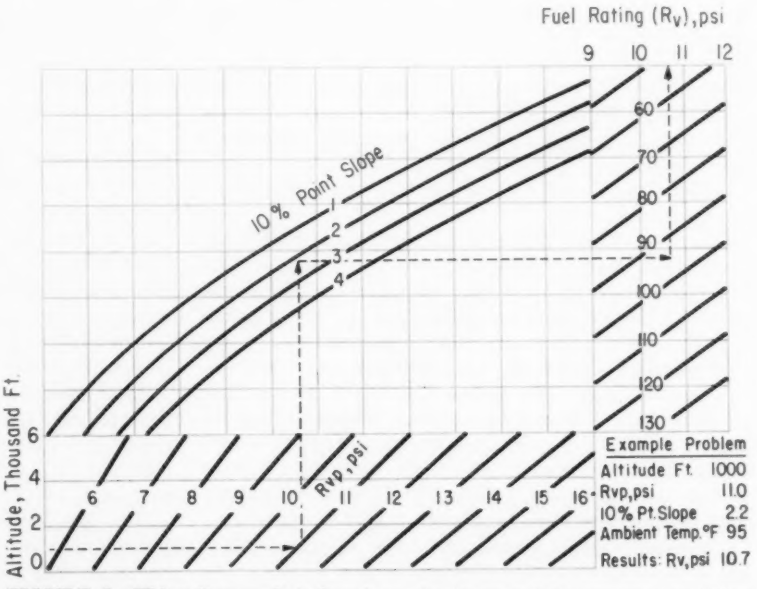


FIGURE 8—This nomograph is based on the isovapor-lock concept for filling station motor fuels.

tive. The motor fuel surveys show that 3 percent of gasolines marketed in 1956-57 had R_v values of 11 or higher. In terms of the temperature-V/L concept, a R_v value of 11 corresponds to V/L ratio of about 30. The relationship can be used to develop specifications for different localities based on a pre-selected value for R_v.

The foregoing relationship has been used to show the large spread in the volatility of fuels marketed at any one time in a given area; also the "seasonal lag" in changing fuel quality in the spring and fall of the year.

Hebl[48] developed a method for vapor lock control which is somewhat similar to that proposed above by Legatski, et al.[53] Temperature is used as the basis of measurement rather than vapor pressure. Volatility tolerance is expressed in terms of a constant C, which is equivalent to a number on the Fahrenheit scale. The relationship is dependent upon Rvp and the slope of the distillation curve is taken at the 15 percent point. Values for C range from around 220 to 225 and are determined by direct test of U.S. vehicles and study of marketed gasolines. Once a value of C is established for the car population, proper values for Rvp and slope can be derived according to the expression:

$$C = t_a + 115 \log (\text{Rvp} + \text{barometer drop}) + V(2 - S)$$

where

- C = temperature tolerance constant of the car's fuel system. (avg. value = 220)
- t_a = atmospheric temperature, °F.
- S = one-tenth of the difference between ASTM distillation 10% and 20% temperatures.
- V = relative vapor-handling capacity of the car's fuel inlet system. (avg. value = 5)

Rvp and barometer drop (from 14.7) are in psi.

Results using this formulation with the recommended value of C (220) correspond to those obtained using an R_v value of 11 in the Phillips isovaporlock method.

General Motors Vapor Pressure. The use of vapor pressure bombs[36, 47] having vapor-liquid ratios corresponding to those encountered in vehicles under vapor locking conditions has also been suggested. Caplan and Brady have proposed a modification to the Reid vapor pressure method which substitutes a 25/1 vapor-liquid ratio in the test bomb.[16] With this procedure, the tendency of a fuel to vaporize (beyond 25/1) is measured almost at the limiting V/L of the average fuel system. Road tests have indicated that this ratio would give good correlation with vapor lock severity among fuels pressurized with different agents. An example of such results is illustrated in Figure 9[16] where acceleration time from 10 to 60 mph is shown as a function of vapor pressure at a V/L ratio of 25.

The General Motors vapor pressure (GMvp) is useful to the automotive engineer in designing and testing the characteristics of fuel systems. No single GMvp value, however, has yet been developed to indicate freedom from vapor lock in any percentage of U.S. vehicles. Thus, the value of GMvp for the control of volatility levels is not known at the present time.

Another benefit cited for this method is that it minimizes the effects of fuel evaporation losses during vapor lock tests.

Validity of Methods. The various methods just described are technically sound. The shortcoming of each

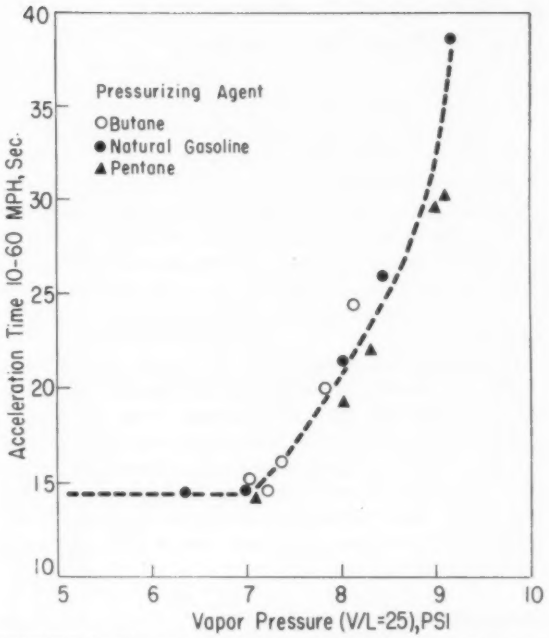


FIGURE 9—Vapor lock severity can be related to the vapor pressure measured at a V/L of 25 (Data for one car shown).

is determination of the level of vapor lock control. In every method, there are two general approaches to setting limits:

- Evaluation of the volatility characteristics of gasolines successfully marketed throughout the country over a period of years.
- Road tests to determine levels of vapor lock tolerance.

The first approach is actually a comparison of one motor fuel with the competitive fuels in the same marketing area. The method provides an indirect measure of how a fuel conforms to the appetite of cars. No prior knowledge of the limiting vapor lock tolerance of cars is required. The measure of vapor lock performance in this case is the number of complaints received or the percentage of market satisfaction (theoretically reflected in the amount of gasoline sold) for a given level of volatility. It is assumed no problems are encountered with successfully marketed fuels.

In practice, the marketer of an average fuel will probably receive occasional volatility complaints. When fuels are more volatile than the average, it is likely the complaint level is higher. However, most refiners and marketers also desire an indication of volatility control on the road and a more basic study is necessary.

In the second approach, volatility limits are derived from actual road test results. The problems here are:

- Translating test (vapor lock) results to normal operation of the car by the owner. Differences are the manner of vehicle operation and sensitivity of trained test personnel as compared with the average driver.
- Using a few cars tested to represent the entire car population.

- Possible differences in fuel volatility at the time of vapor lock in the road test and the volatility of fuels as blended at the refinery.

Success in setting specifications via road tests depends upon the selection of realistic ambient temperatures and V/L ratios. Assuming that proper V/L limits can be determined from test results, this approach yields a firm basis for controlling volatility since limiting specifications are set by considering basic principles for vapor formation.

Experience has shown that the results of road tests (CRC procedure) are more severe than actual conditions encountered by the consumer. For this reason, specifications set by road tests alone may be less volatile than fuels normally marketed. Correction factors may be applied to volatility limits to include marketing experience. The temperature-V/L curve provides a convenient means of tempering test results with marketing experience in any area.

Comparison of Methods. During recent years, the temperature-V/L correlations presented by CRC have been questioned as to applicability to modern gasolines. For example, Sheppard and Withers[85] indicated the correlations do not have universal application. Based on about 60 commercial fuels, calculation of the temperatures for a V/L of 36/1 using the CRC relationships did not agree with results measured in the laboratory by the Sunbury apparatus. However, a 36/1 ratio is usually higher than is normally calculated for evaluation work. On the other hand, results of random checks on various fuels plus data recently published for military fuels[11] show good agreement between calculated and measured results. The CRC calculations generally yield accuracy within the variation of test equipment. Most studies show the correlations to be as valid for today's fuels as for commercial fuels when initially developed.

TABLE 2—Relative Volatility As Ranked By Various Test and Calculation Methods*

Sample No.	Observed Temp. In Sunbury Test At V/L = 25, °F	Calculated Temp. By CRC Method At V/L = 25, °F	Rvp, psi	GMvp, psi	ASTM Percent Evaporated At 158° F	Phillips Isovapor Lock Rating Scale, Rv
9	159[1]	159[1]	7.2[1]	6.0[3]	14	10.0[1]
20	159[1]	159[1]	7.0[3]	5.9[4]	19[1]	8.6
2	160[2]	161[3]	6.8	6.1[2]	14	8.6
5	160[2]	163	7.2[1]	6.2[1]	12	8.6
12	160[2]	162[4]	7.1[2]	5.9[4]	13	9.0[4]
13	160[2]	172	6.2	5.7	9	8.0
17	160[2]	160[2]	6.5	5.6	16[3]	8.8
3	161[3]	161[3]	6.3	5.5	15[4]	8.5
15	161[3]	165	6.2	5.6	16[3]	8.5
18	161[3]	160[2]	6.7	5.8	18[2]	8.0
6	162[4]	165	6.9[4]	5.8	11	8.5
7	163	166	5.9	5.7	13	8.0
10	163	166	6.7	5.6	14	9.2[4]
11	163	160[2]	7.2[1]	5.8	13	8.8
8	164	165	7.1[2]	6.0[3]	9	9.5[2]
16	164	166	6.8	6.0[3]	10	8.0
14	166	165	6.3	5.4	14	8.0
30	167	167	6.8	5.7	9	8.1
19	170	176	5.3	4.8	12	8.0
22	170	175	5.5	4.8	8	8.0
23	170	180	4.3	3.9	4	8.0
24	170	171	5.8	4.9	12	8.0

* Arranged in order of decreasing volatility according to observed Sunbury test results.
[1] Most volatile according to method.
[2] Second most volatile according to method.
[3] Third most volatile, etc.

A comparison of methods of volatility control was made in connection with a recent study of the vapor locking characteristics of military fuels.[11] Results of this study are shown in Table 2. The Sunbury apparatus was used as the absolute measure of relative volatility. Ranking of the fuels by each of the following tests or fuel variables was accomplished by a comparison with observed temperatures at a V/L of 25:

- Rvp
- GMvp
- R_v (Phillips isovapor-lock chart)
- % evaporated at 158° F
- Temperature at V/L of 25 as calculated by the CRC procedure.[21]

It can be noted that the calculated temperature-V/L values agree well with the observed values. Further, the CRC calculation procedure ranked the fuels closest to the ranking of the Sunbury test apparatus.

HOT STARTING

Difficult hot starting usually takes place after the engine has been stopped following a high power output run. Since the vehicle is not in motion, hot air normally swept out of the engine compartment rises around the carburetor. Temperatures of 60-70° F above ambient are not unusual in the carburetor at this time.[22,103] During this heat soak-up period, a volatile fuel will vaporize in the carburetor float bowl and passages.

With internally vented carburetors, vapor expands directly into the carburetor barrel and manifold. If such venting is not provided, or is inadequate, pressure will build up above the fuel in the float bowl. When this happens, expanding vapor bubbles can cause liquid fuel to rise and flow over the liquid head in the discharge nozzle. This latter process is commonly referred to as percolation.

Such vaporization results in both a shortage of fuel in the carburetor and a surplus of fuel in the manifold. Under this flooded condition, starting is difficult. Cranking the engine with the throttle fully-open will eventually force accumulated fuel out through the exhaust ports. If the level of fuel remaining in the float bowl is low, a period of "fuel starvation" then will follow until sufficient gasoline is pumped to the carburetor to permit starting.

Hot starting problems have been alleviated by a carburetor design which vents fuel vapor from the float bowl directly to the atmosphere rather than into the carburetor barrel and manifold.

HOT IDLE

Hot idle problems are most likely to occur in hot weather during idling in traffic or immediately following a period of full-load engine operation. Low-speed operation promotes heat soak-up by the fuel system, causing vapor formation in the carburetor (or in the fuel line immediately ahead of the carburetor). Overly rich air-fuel mixtures can result by the same mechanisms

of vapor expansion as described under hot starting. The processes continue until heat is dissipated and boiling ceases.

Vaporization frequently enriches the air-fuel mixture sufficiently to cause flooding. This results in loss of power, misfire, rough idle, surging, and even stall (which may be further aggravated by difficult hot starting). Heat transfer to the carburetor by conduction and radiation is an important factor.

Some improvements have been made in the design of carburetors and manifolds to relieve flooding. Many carburetors now incorporate external vent valves or "anti-percolators." However, under severe conditions, the vent may not be able to handle the volume of vapor formed. Such corrective measures also contribute to air pollution.

The same fuel factors and atmospheric conditions apparently affect hot starting and idle as affect vapor lock, but experience has shown they are less critical of volatility than vapor lock. This means that a fuel controlled for vapor lock will generally prove satisfactory with regard to flooding probems.

Cold Weather Problems

Volatility problems during cold weather operation stem from insufficient fuel vapor reaching the cylinders to permit easy starting and rapid warm-up. In cold weather enough fuel must evaporate to supply the cylinders with a combustible mixture for starting. In addition, vaporization at manifold temperatures existing during warm-up must be sufficient to provide a suitable air-fuel mixture for smooth car performance.

The choke, of course, supplies an excess of gasoline which, in turn, supplies additional vapor. But, cold starting can be particularly difficult since the mixture temperature actually will be reduced below ambient due to the latent heat of vaporization of light portions of the fuel. Also, the low intake air velocity and essentially atmospheric pressure in the manifold during cranking are not conducive to vaporization. To overcome this, extremely rich mixtures having air-fuel ratios of 1-to-1 (winter) to 2-to-1 (summer) are provided to promote fast starting. When the engine is cold the choke closes, allowing full intake manifold vacuum to act on the main fuel nozzle. As the car warms up the choke gradually opens automatically, with the amount of choking dependent on engine design. (Such operation is performed manually if the vehicle is so equipped.) Vaporization during warm-up is promoted by rapid heating of the intake manifold "hot spot" with diverted exhaust gas.

Engine problems normally assocated with cold weather are starting and warm-up. While carburetor icing is often considered a cold weather problem, it occurs at temperatures from 30 to 50° F and is actually one of too much, rather than too little, volatility. In areas subject to large variation in temperature, or during the fall and spring of the year, control of these problems demands a careful compromise when fuel specifications are established.

COLD STARTING

Cold starting trouble occurs when a fuel does not vaporize sufficiently at low temperatures. Thus, a flammable mixture of fuel vapor and air does not reach the engine cylinders even though the choke may supply 10-20 times the amount of liquid gasoline normally necessary for firing. The gasoline must contain roughly 5 to 10 percent of hydrocarbons light enough to vaporize under starting conditions.

Tests have shown starting becomes an important fuel volatility problem at temperatures below 20° F. Between 40° and 20° F, neither fuel volatility nor ambient temperature are critical with the normal range of winter gasolines and starting is usually satisfactory. This is shown in Figure 10 which is based on data obtained by

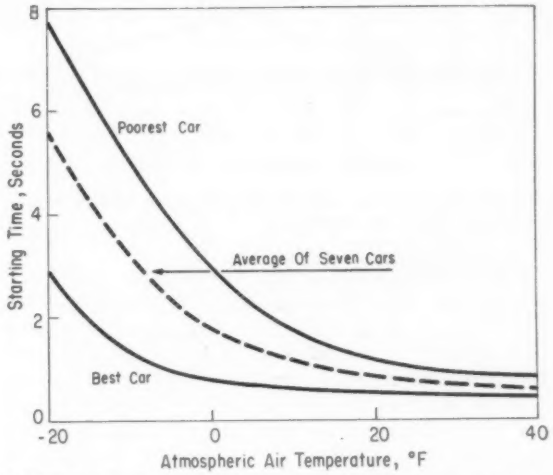


FIGURE 10—Starting becomes an important fuel volatility problem at temperatures below 20° F. For these data, test fuels were used having 35% evaporated at 158° F.

Moore, et al.[64] The time required to first fire is a practical criterion for measuring cold starting requirements.

Cold starting is directly affected by the amount of light ends (primarily butanes) in the motor fuel blend. The commonly used terms to define starting performance of a fuel are Rvp, the 10 percent evaporated temperature, 10 percent point slope, or the percent evaporated at a certain temperature, such as 158° F.

A method of relating fuel characteristics to engine starting is presented in the 1946 CRC Handbook.[21] Minimum temperatures for both "satisfactory" and "possible" starting are mathematically related to the 10 percent evaporated temperature and 10 percent slope of the ASTM distillation. Satisfactory starting is defined as a start within ten crankshaft revolutions (approximately 6-7 seconds at 0° F for modern engines.) Assuming that a 1:1 air/fuel mixture is supplied by the choke, the required percentage of fuel evaporated for possible and satisfactory starting was determined to be 5.0 and 7.9 percent respectively. Typical values for satisfactory and possible minimum starting temperatures with a 1:1 mixture using the derived relations are shown in Table 3. The exact correlations would be different for today's engines but the effects of front-end volatility are just as significant as those shown in the table. Also, the relative starting performance of fuels is very likely the same.

Recently, Legatski, et al.[55] reviewed the changes in volatility necessary with changing temperature to main-

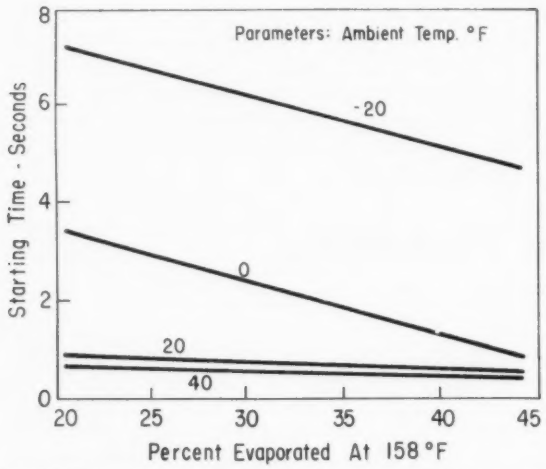


FIGURE 11—Average starting time for seven 1956 passenger cars shows effect of volatility.

tain the same ease of starting. For example, a decrease of about 14° F in 10 percent point is needed to offset each 10° F drop in ambient temperature (10 percent slope constant). In addition, a fuel with a 10 percent point slope of 1 can have a 13° F higher 10 percent point temperature than a fuel with a 10 percent slope of 4 and still give equal starting performance at constant ambient conditions. Air-fuel ratio at the carburetor also is constant for both observations.

Domke, et al.[24] investigated the cold starting problem in 1949 cars and found the 158° F point provided a more consistent measure of starting time than the 10, 20 or 30 percent points.

The effect of fuel volatility on cold starting performance in seven 1956 cars, as measured by the percent evaporated at 158° F, is illustrated in Figure 11.[64] The fuels used in this study ranged from 11.5 to 12 Rvp. Below 20° F, starting ability improves as front-end volatility is increased. At temperatures of 0° F and below, starting time decreased one second for each 8 percent increase in fuel evaporated at 158° F. The relatively large difference in starting time between 0° F and —20° F indicates that the minimum temperature at which good starting is needed, has a marked effect on fuel volatility requirements. For example, if a starting time of 2 seconds is desired in 0° F weather, at least 33 percent of the fuel must evaporate at a distillation temperature of 158° F. If the ambient temperature drops to —5° F, the minimum percent of fuel off at 158° F should increase to 42 percent for equal starting ability. Starting performance has also been evaluated in 1958 and 1959 model cars and effects of fuel volatility are about the same as for earlier cars.

TABLE 3—Minimum Ambient Temperature Required for Starting as Affected by the ASTM Distillation of the Fuel

10% Evap., °F (t_{10})	10% Slope (S_{10})	Temp. Needed for Starting, °F	
		Satisfactory (t_s)	Possible (t_p)
100	2.5	—29	—47
120	3.0	—15	—34
140	3.5	— 1	—21
160	4.0	13	— 8

Note: $t_s = 0.679\ t_{10} - 100.7 + 2.5\ \sqrt{S_{10}}$

$t_p = 0.657\ t_{10} - 110.8 - 1.2\ \sqrt{S_{10}}$

TABLE 4—Minimum Percent of Fuel Evaporated at 158° F For Satisfactory Cold Starting (Average 1958-59 Cars)

Ambient Temp., °F	Rvp, psi	10% Pt, °F	Min. % Evap. at 158° F
0	12.5—13.5	110—115	30
10	13.0—13.5	102—103	30—35
20	12.5—13.5	110—115	30
30	10.5—11.0	114—116	20—25
50	9.5—10.0	122—127	20—25

Definite volatility limits for good starting are impossible to assign because of the wide differences in starting characteristics among cars. Satisfactory starting has been defined, however, in terms of minimum percent of fuel evaporated at 158° F. Data shown in Table 4 represent average performance in six cars at ambient temperatures from 0° to 50° F. Ranges in Rvp and 10 percent point for the fuels tested are shown. The criterion for limiting volatility was either a significant increase in starting time or complete stalling. The minimum percent evaporated at 158° F ranges from about 35 percent at temperatures approaching 0° F to 20 percent at 50° F.

From a cold starting standpoint alone, gasoline quality increases as its initial volatility increases. This is in direct conflict with fuel properties necessary to avoid vapor handling problems. The conflict rises from the need to avoid vapor lock during unusual high temperature periods in the spring and fall of the year. The problem also occurs during the winter in certain geographical areas. Legatski[55] points out that not only is there wide variation between the maximum and minimum temperatures for a given month in any location, but also that the variation in minimum temperatures

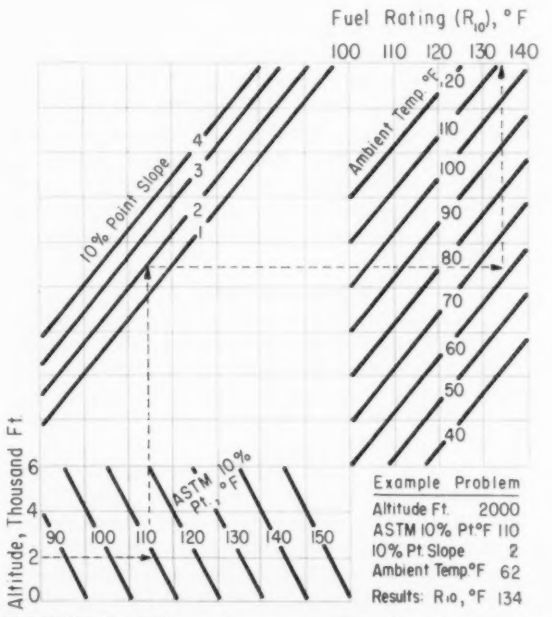


FIGURE 12—This performance rating chart incorporates vapor lock control as the limiting feature.

is about twice that for maximum temperatures. This makes it impossible to control both vapor lock and cold starting for every set of conditions.

A performance rating chart[13] has been developed for engine starting which incorporates vapor lock control as the limiting feature. The rating chart, (Figure 12) is based upon the 10 percent point temperature and 10 percent point slope. Altitude and maximum temperatures are taken into account. The rating number R_{10} is the 10 percent evaporated temperature of a hypothetical fuel of 10 percent point slope = 2 that would exhibit the same freedom from vapor lock (at 100° F and sea level) as a gasoline under its conditions of use.

This method implies vapor lock should be controlled at the expense of cold starting. In fact, motor fuel surveys of gasolines marketed over a three-year period provide evidence that front end volatility is controlled in practice by vapor lock, rather than starting considerations.[13] The performance rating chart introduces a compatability control factor (R_{10}) with best and most consistent performance in starting by following vapor-lock limited volatility as closely as possible. Typical R_{10} values have been determined for motor fuels marketed in the United States and values of 115 are considered conservative. This corresponds to an R_v value for vapor lock control of about 11. An R_{10} rating of 125 ($R_v = 9$) is stated as "ultra conservative."

Other big factors affecting the relation between starting time and fuel volatility requirements are battery output and viscosity of engine and transmission fluids. For example, the available output of a fully-charged battery at temperatures below 10° F, may be less than 50 percent of rated capacity. Oil viscosity is also greatly affected.[102] Engine cranking speed is shown as a function of temperature in Figure 13.[93] At cranking speeds below 40 rpm, starting becomes doubtful. Low ignition voltages and/or cranking speeds are common faults when starting is difficult.

Of course, any degree of mechanical maladjustment or weakness with regard to ignition system or carburetion can be expected to aggravate the situation. For the average driver, then, the problem is even more critical than it is for the cars discussed above which were in "near-perfect" condition.

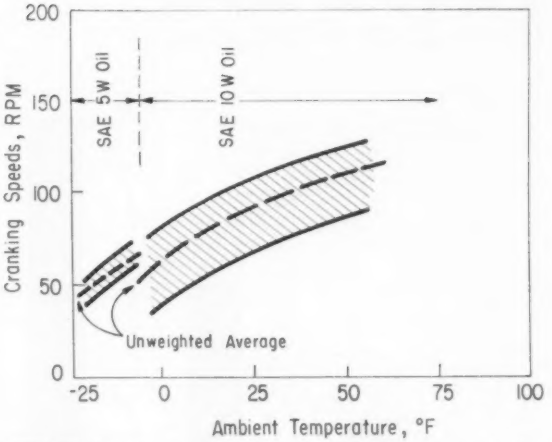


FIGURE 13—At cranking speeds below 40 rpm, starting becomes doubtful.

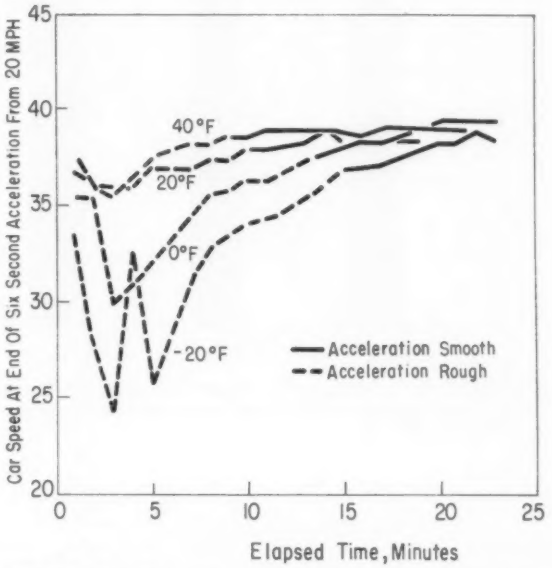


FIGURE 14—Here are typical performance data for a vehicle under adverse conditions during the warm-up period. The fuel had a 50% evaporated point of 193° F.

WARM-UP

Typical performance of a vehicle under adverse conditions during the warm-up period is illustrated in Figure 14.[64] In accordance with test methods described by Taylor and Gibson,[95] car speeds attained at the end of 6 second accelerations from 20 mph are shown during the time of warm-up. The first accelerations after starting are relatively good since the choke supplies extra fuel, and hence sufficient vapor, to the engine. Performance drops off as the automatic choke begins to open. In this case, opening at lower temperatures occurs too soon relative to fuel volatility and the air-fuel ratio becomes excessively lean. Succeeding accelerations result in a recovery of speed until, in about 10-15 minutes, performance becomes smooth. In 15-20 minutes, the vehicle has essentially warmed-up and maximum speed is constantly reached.

Warm-up performance becomes more critical as ambient temperature drops. Warm-up behavior also is shown as a function of temperature in Figure 14. Exact effects of temperature will vary with different fuels and cars. For the combination shown in Figure 14, there is greater difficulty when the temperature drops below 20° F.

The most critical time during warm-up occurs when the automatic choke begins to open. There is a large variation in the operation of automatic chokes. Aside from manifold heating, this is the greatest single controllable design factor which affects warm-up. Some car manufacturers allow chokes to open readily to attain maximum economy even though car performance may fall off badly after the first two or three minutes of warm-up. Others use slow-opening chokes to improve warm-up at the expense of economy. Examples of choke operation and the corresponding effects on fuel economy during the warm-up of two 1956 passenger cars[64] are shown in Figure 15.

The economy of Car A, with fast-opening choke, can be compared with that of Car B, which had a slow-

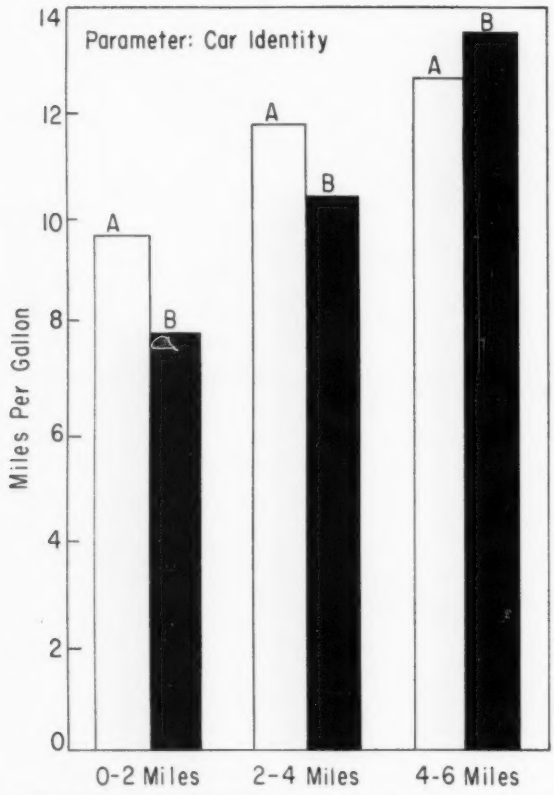


FIGURE 15—Choke operation affects fuel economy. Car A has the faster-opening choke. Each bar is an average of runs at 0, 20, and 40° F.

opening choke. At equilibrium warm-up conditions, the fuel economy was nearly the same for the two vehicles. However, during the warm-up period (0-4 miles), Car B suffered a loss in fuel economy relative to Car A. For constant choke operation, altering the volatility of a fuel to obtain better warm-up characteristics does not appear to affect economy.

Volatility of a fuel in the mid-boiling range affects greatly the warm-up performance of an engine. Specifically, the 50 percent evaporated temperature and, to a smaller degree, the 90 percent temperature have been found to control warm-up. The shape of the distillation curve within this range also is important.

A fuel which is too heavy will cause rough accelerations and stall during the warm-up period. The time required to warm-up until smooth accelerations are attained will be lengthened considerably when a fuel is not sufficiently volatile. In fact, rough performance can be encountered even long after reaching equilibrium warm-up temperatures. The effects of volatility are illustrated in Figure 16.[64]

A correlation developed by Holaday and Heath[50] related the 10, 50 and 90 percent evaporated points to the miles driven until warm-up at various atmospheric temperatures. The relation was based on data obtained in 1938-39 passenger cars driven at a constant warm-up speed of 10 mph until smooth accelerations were obtained. Each change of 20° F in one of the distillation points, while keeping the other two constant, produced the following respective changes in miles to warm-up: 10 percent point—0.5 miles; 50 percent point—0.3 miles; 90 percent point—0.1 miles (at 10 mph, 0.1 mile difference equals 0.6 minutes). Front-end volatility was significant in this study.

A similar program repeated in the mid-1940's[50] indicated that the average 65 percent point (average of 40, 50, 60, 70, 80 and 90 percent points) also has good correlation with warm-up time. Further, the 50 percent point has about twice the effect of the 90 percent point.

Later, Taylor and Gibson[95] showed the 50 percent point had the greatest influence on warm-up and also that the 10 and 90 percent points affected initial and final warm-up respectively. These tests were conducted under accelerating conditions to more closely simulate consumer conditions.

The shape of the distillation curve was studied in order to determine the relative significance of the 10, 50 and 90 percent points. While definite relations were not established, each distillation point appeared to have its primary influence during respective parts of the acceleration.

Domke, et al.[24] found warm-up time could best be related to the 50 percent point and the percent evaporated at an ASTM distillation temperature of 158° F. It was concluded the 90 percent point had little influence on warm-up. In the correlations developed, increasing 50 percent point by 20° F with no change in initial volatility resulted in increasing the warm-up time by 0.5 minutes. On the other hand, a change in the amount evaporated at 158° F by 10 percent (at constant 50 percent point) changed warm-up time by about 0.6 minute.

Stone and Bier,[93] in a study involving 1950-51 model cars also found the 50 percent point to be the controlling factor in warm-up. They further concluded the

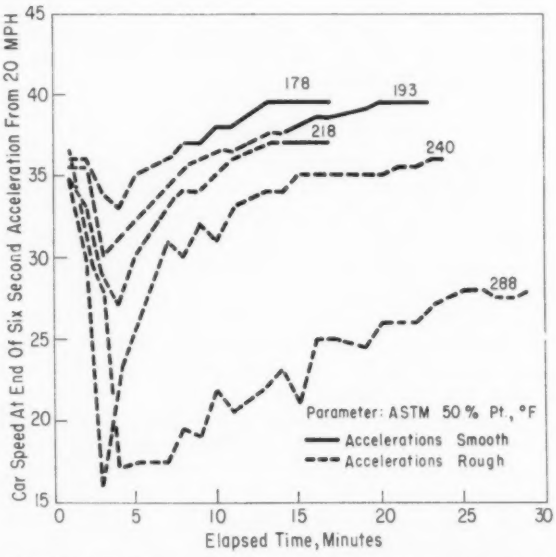


FIGURE 16—These data were taken at 0° F atmospheric temperature using a fuel with a 35% evaporated point of 158° F and 90% points in the range of 312 to 339° F.

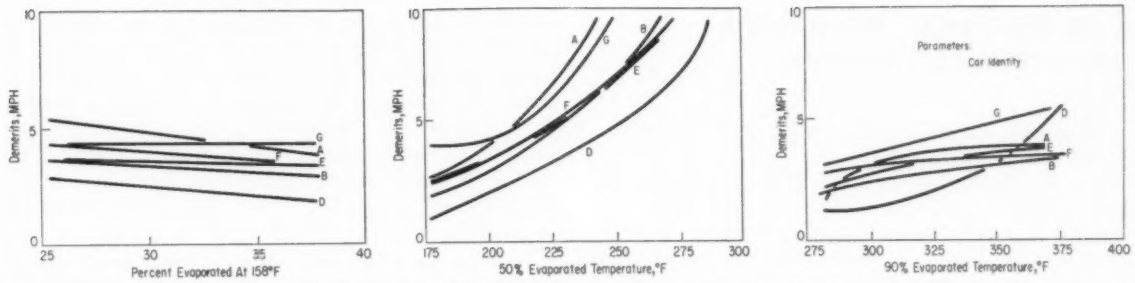


FIGURE 17—Of these three variables, the 50% point had the greatest influence. For the variations in 50% point, the fuels had 35% points of 158° F and 90% points of 309° F.

effect of the 10 percent point on warm-up performance was significant only under severe conditions; that is, with a fuel of very high 50 percent point or under extremely low temperatures. Effects of changes in the 90 percent point were unimportant.

In a more recent study, the warm-up characteristics of 1956 model cars were investigated.[64] In evaluating the data, a "demerit" system of rating was devised to measure the performance of fuels relative to a "perfect fuel." The demerit rating is the difference in acceleration speed in miles per hour with the test fuel compared to the perfect fuel. The individual effects of percent evaporated at 158° F, 50 percent point and 90 percent point on warm-up behavior are illustrated in Figure 17. The poorer the performance of a fuel, the greater are its demerits.

The effect of front-end volatility is small over the range investigated. In contrast, demerits increase rapidly with increasing 50 percent evaporated temperature. In addition to emphasizing the importance of the 50 percent point, the curves also tend to level out as the 50 percent temperature drops, suggesting there is an optimum temperature beyond which no further improvement will occur. In comparison with the 50 percent point, back-end volatility has a lesser, but significant, effect. A recent study by Dugan[27] also has shown the 90 percent point has a definite effect on warm-up. Even at ambient temperatures as high as 30° F, two fuels differing only in 90 percent point (307° to 360° F) differed by 3 minutes in warm-up time in six 1955 cars. At 0° F, the difference in warm-up time increased to as much as 22 minutes.

The mid-range and final volatility have been related to the warm-up performance of a particular car at various ambient temperatures, as shown in Figure 18.[64] With the demerit system, a rating of more than 3 would probably be unsatisfactory. The problem of exact rating of the warm-up performance of fuels is illustrated in Figure 19.[64] Both of the fuels shown have the same demerit rating. However, Fuel 5 shows a lack of acceleration ability for a relatively long period while Fuel 1 yields poor performance immediately after starting but recovers quickly. A choice between these fuels would be difficult with any rating system, but the deficiency of Fuel 1 would more likely be noticed by the average driver.

A summary of the above investigations show warm-up performance is controlled to the greatest extent by the mid-range of the distillation curve (50-70 percent portion) and to a lesser extent by the front and back-end.

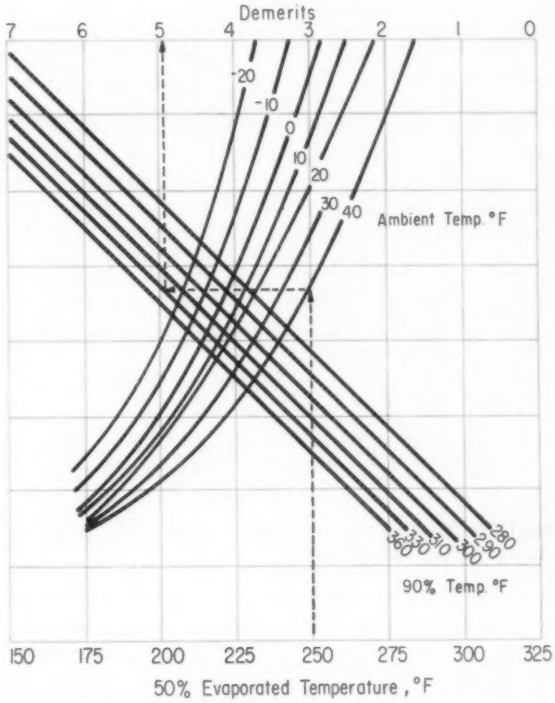


FIGURE 18—The greater the demerits, the poorer the performance of a fuel.

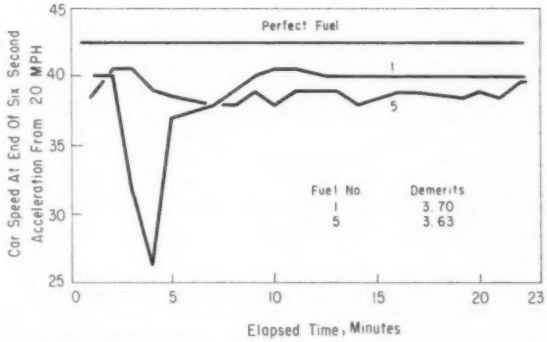


FIGURE 19—The deficiency of Fuel 1 would more likely be noticed by the average driver.

The 90 percent point is more significant than the 10 percent point. While the 50 percent evaporated temperature is used in most cases, a slightly higher distillation point may be more effective. For example, good

correlation of the average 65 percent point with warm-up is shown in Figure 20.

The selection of optimum volatility for warm-up depends upon the minimum temperatures for which fuels must be designed. By examining Figure 18, it is observed that at an ambient temperature of —10° F, a fuel with a 90 percent point of 300° F should have a 50 percent point not greater than 196° F to rate 3 demerits in this car. However, at 10° F ambient, this fuel could give the same degree of warm-up with a 50 percent point of 208° F. Based on an average of all data obtained by Moore, et al.[64] it appears that at 0° F atmospheric temperature, the average maximum 50 percent point should be around 200° F. Depending on the car, limiting maximum values ranged from less than 178° to 225° F. These mid-range values are for fuels with 35 percent distilled at 158° F and a 90 percent point of 309° F.

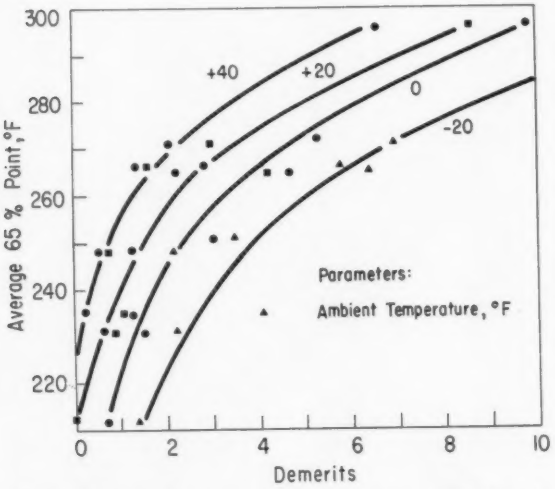


FIGURE 20—The demerit system correlates well with the average 65% points of fuels.

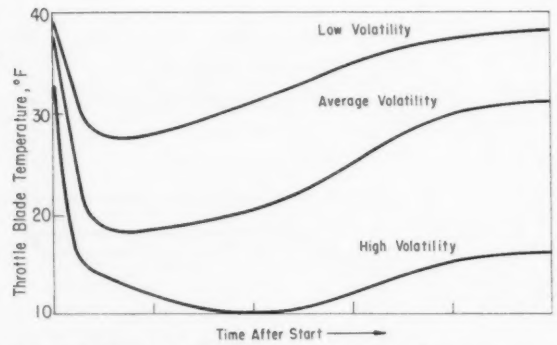


FIGURE 21—As a fuel evaporates it lowers the temperature of the metal parts in a carburetor.

TABLE 5—Warm-up Performance in 1958 Passenger Cars

Ambient Temp., °F	FUEL RATING, DEMERITS			FUEL INSPECTION			
				Rvp, psi.	ASTM Distill., °F		
	Car A	Car B	Car C		10%	50%	90%
0	17.2	6.3	20.0	13.7	109	236	327
	3.6	2.9	11.6	12.7	114	203	328
	2.9	3.7	6.5	12.9	102	183	305
20	8.9	5.7	12.7	13.7	109	236	327
	3.5	3.4	5.2	12.7	114	203	328
	3.2	3.6	5.7	12.9	102	183	305

Warmup performance tests conducted in 1958 and 1959 model cars resulted in similar conclusions. Warm-up behavior in 1958 cars is shown in Table 5. Three fuels of different volatility were rated at ambient temperatures of 0° to 20° F. The demerit rating system suggested by Moore, et al.[64] was used to evaluate performance. Although there is wide variation among cars, it can be seen that at both test temperatures, the fuel with a 50 percent point of 236° F shows relatively poor performance. This is true despite its higher Rvp. A 50 percent temperature as high as 203° F gives satisfactory performance in these cars.

Tests have been conducted in three 1959 passenger cars at atmospheric conditions 0°, 30°, and 50° F. One of these cars exhibited such poor performance that at 0° and 30° F, it failed to operate satisfactorily on a fuel having a 50 percent temperature as low as 186° F. At 50° F, this car performed well with a fuel of 219° F-50 percent point and tolerated a 50 percent temperature of 238° F. The other two cars tested were more typical of the average automobile. Maximum 50 percent temperatures for satisfactory warm-up performance at ambient conditions of 0°, 30°, and 50° F were shown to fall in the range of 216° F, 224° F and 238° F, respectively. Corresponding 90 percent points for the gasolines tested ranged from 307° to 334° F.

Decreasing the mid-volatility of a fuel to promote good warm-up performance is also contrary to the blending scheme for avoiding vapor handling problems. Although vapor formation is controlled mainly by front-end volatility, it is also affected by the mid-portion of the ASTM distillation.

CARBURETOR ICING

Carburetor icing refers to ice formation in the carburetor during warm-up. This problem has come into the limelight as its effect on engine stalling has become more evident in recent years. The mechanism of icing itself may be described as follows:

As fuel evaporates it lowers the temperature of the air entering the carburetor and surrounding metal parts. If the ambient temperature is low enough and the fuel sufficiently volatile, temperature of the metal is quickly lowered below 32° F. Any moisture in the in-coming air that contacts these metal parts will deposit as ice. This ice usually appears first on the throttle blade and carburetor barrel near the throttle blade. When enough moisture is present in the in-coming air, ice continues to build up until the entire top and edges of the throttle blade are coated. When the throttle is closed for idling, the ice present reduces air flow past the throttle blade until engine speed is reduced to the stalling point.

As the engine warms up, ice formed on the center of the throttle blade may melt, break up and flow to the edge of the blade, and again restrict air flow. Although

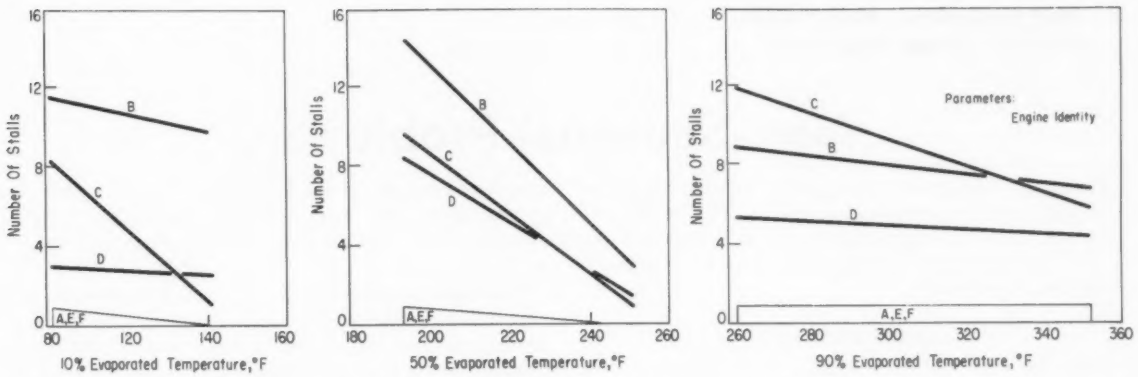


FIGURE 22—These stalling data were taken when the ambient temperature was 40° F and the relative humidity was 100%.

the engine usually can be restarted immediately, ice formation and tendency to stall may last as long as ten to twenty minutes under severe conditions.

There is also another form of icing that has been observed in some engines during steady high-speed driving on cool, damp days. Large quantities of air passing through the carburetor may result in gradual ice build-up within the venturi. This ice restricts the venturi and increases metering vacuum and, consequently, fuel flow. This results in an excessively rich mixture which causes power loss and high fuel consumption.

There is considerable variation among engines in regard to carburetor icing susceptibility. Two engine characteristics stand out as most critical: Fast idle speed and throttle blade temperature.

A fast idle setting holds the throttle blade open and presents a wide gap to be bridged by ice. With automatic transmissions, fast idle adjustment is not a satisfactory solution because it introduces the problem of transmission "creep."

High throttle-blade temperature minimize the amount of ice formed. This temperature, of course, is a function of both the heat transfer to the carburetor from the manifold and also the volatility of the fuel. Caution must be exercised in the matter of heat supplied to the carburetor, otherwise percolation will be promoted in hot weather. The cooling effect of evaporation on blade temperature for fuels of low, average and high volatility is shown in Figure 21.[29]

Icing can occur over a fairly wide range of weather conditions depending on gasoline volatility.[7,29] For the fuel of average volatility, critical ambient conditions range from about 35 to 45° F at relative humidities above 75 percent. For more volatile fuels, the critical range is greater—about 30 to 50° F at relative humidities in excess of 65 percent. Regardless of the fuel the conditions most conducive to icing are 40° F and 100 percent relative humidity.

The effects of various parts of the fuel boiling range on stalling due to icing have been thoroughly studied and the results of one investigation are shown in Figure 22.[29] Since some engines are much more prone to icing, the problem varies considerably from car to car. Figure 22 illustrates that the 10 percent point influences the number of stalls in engines susceptible to icing. Variations in the 50 percent point have a much greater effect since stalling was largely reduced by increasing 50 percent point. The 90 percent point also has a small effect on stalling tendency.

Icing can be controlled primarily by the 50 percent point, with lesser control available through the 10 and 90 percent points, in that order of importance according to many papers in recent years. Figure 22 suggests the tendency of a fuel to cause icing can be greatly reduced by maintaining a mid-temperature of at least 240° F.

The use of additives is a fortunate alternate route to icing control, since the volatility requirements to prevent icing are directly in conflict with those for satisfactory warm-up. Anti-icing additives fall into two categories: (1) freezing point depressants, such as isopropanol, and (2) surfactants. Surfactants change the surface tension of the fuel with respect to metal surfaces of the carburetor. Agents in use today usually offer additional advantages, such as, corrosion inhibition and detergency and are effective in very low concentrations where light to moderate icing exists. Severe conditions encountered with a highly volatile fuel generally require an alcohol-type additive for control.

The effect of volatility and additives on stalling due to icing is illustrated in Table 6. The incidence of stalling in two recent-model cars with a volatile fuel is greatly reduced by the use of various additives. Since additives vary in effectiveness between cars on a concentration basis, cost-effectiveness usually determines the choice for particular motor fuels.

TABLE 6—Effects of Fuel Volatility and Additives on Stalling Due to Carburetor Icing

Fuel	Additive	No. OF STALLS	
		Car A	Car B
Volatile	None	8.5	7.0
Average	None	1.0	2.0
Heavy	None	0	1.0
Volatile	0.5% IPA[1]	1.3	0.7
Volatile	1.0% IPA	0	0
Volatile	50 ppm MPA[2]	2.5	1.7
Volatile	100 ppm MPA	2.5	0.7

[1] Isopropyl alcohol.
[2] Surface active agent.

Non-Seasonal Problems

There are also some non-seasonal factors connected with fuel volatility and car operation. The severity of these problems can vary somewhat with the seasons due to driving conditions but they are generally present throughout the year.

ACCELERATION

Here the reference is to engine acceleration after equilibrium temperature has been reached and the choke is fully off. When the throttle is opened suddenly for fast pickup, the flow of air increases more rapidly than flow of fuel. From low to medium speeds, liquid fuel has a tendency to plate out and wet the manifold walls. Furthermore, the greater absolute pressures existing in the manifold at wide-open throttle do not promote vaporization. The combined effects of these factors can cause lean fuel mixtures at the beginning of acceleration. An accelerating pump compensates for these effects by shooting extra fuel into the air stream as the throttle opens.

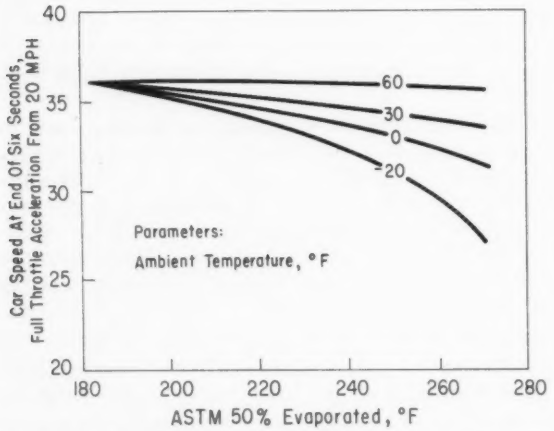


FIGURE 23—The effect of volatility on acceleration performance was determined with the car warmed up and the manual choke open. The test fuels had 10% points of 119 to 124° F.

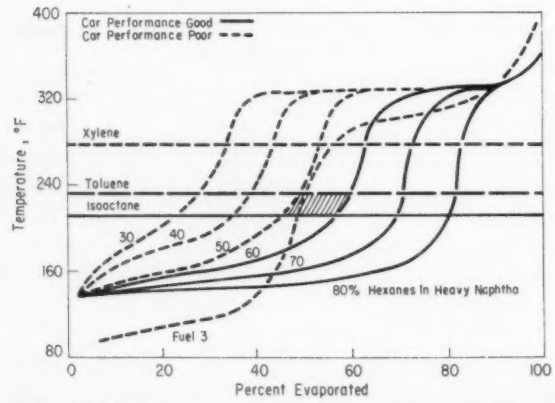


FIGURE 24—At 0° F ambient temperature, warm-up varied with ASTM distillation as shown. The two component fuels were made by blending mixed hexanes (135-137° F) and heavy naphtha (314-330° F).

Optimum acceleration is obtained if the excess fuel vaporizes sufficiently in the engine manifold to form an air-fuel mixture of about 12-to-1 to yield maximum power.[77] With less vaporization due to low volatility in the middle and upper portions of the ASTM distillation curve, leaner mixtures are formed. Both maximum power output and acceleration ability decrease, slowly at first and then more rapidly, as air-vapor mixtures become leaner. Effects of fuel mixture on engine power are shown in an accompanying box. While output is fairly constant over a wide range of air-fuel ratios, it falls off quite rapidly for mixtures leaner than 15-to-1. At ratios of 18 and 20-to-1 acceleration ability may be decreased to as low as 73 and 37 percent respectively, of the maximum attainable.[14]

Stone and Bier[93] related the 50 percent evaporated temperature to acceleration ability at various ambient temperatures from —20° to 60° F. Results in one car are shown in Figure 23 for fuels of varying mid-volatility. A wide variation in 50 percent point has no effect at 60° F, but an increasing effect as atmospheric temperature is lowered. At temperatures as high as 30° F, acceleration ability is reduced about 1 percent for each 10° F rise in the 50 percent point.

High front-end volatility may not necessarily give good performance, since the shape of the distillation curve also is important. Figure 24 shows the effects of a series of hydrocarbons, run individually and in binary blends, on the performance of a fully warmed-up car.[64] Gasolines whose distillation curves fall above or to left of the shaded area (such as Fuel 3 shown) will not provide good acceleration in this vehicle. Such fuels have unusually high 50 percent points and insufficient fuel would be vaporized for good performance at low temperatures.

Relationships between fuel characteristics and engine acceleration are discussed in the 1956 CRC Handbook.[21] In the procedure described, the 90 percent point is the basis for calculation.

A measurement of relative acceleration performance for fuels by means of a rating chart has been developed by Bridgeman and Aldrich.[14] The rating scale for engine acceleration with the choke fully open was based upon a new study of early data developed by Brown.[15] The relations apply to modern cars since they deal with relative acceleration ability and are essentially independent of engine design. The rating scale is defined by the following expression:

$$R_A = 30.2 - 0.1\ [t_{50} + 0.15\ t_{90} - 0.375\ T]$$

where

R_A = Acceleration rating value
T = Sea level equivalent minimum ambient temperature
t_{50} = ASTM 50% evaporated temperature
t_{90} = ASTM 90% evaporated temperature

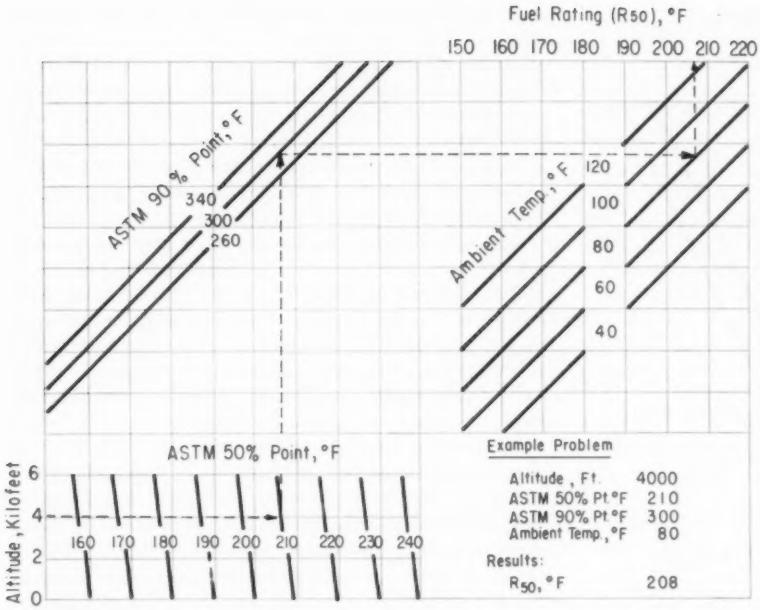


FIGURE 25—This chart will show you the relative acceleration performance for your fuels.

This rating system indicates acceleration performance improves with a decrease in the 50 percent point and, to a smaller degree, the 90 percent point. Acceleration ability determined for fuels with this relationship was found to correlate well with work done by other investigators.[14]

A rating chart based upon the above equation is shown in Figure 25. In this chart, the equivalent 50 percent point (R_{50}) of fuels can be determined which would give the same, constant acceleration performance (R_A) under selected reference conditions. The reference 90 percent temperature is 356° F with ambient conditions of sea level and 100° F. Maximum ambient temperatures are used since vapor lock is considered controlling. The chart may be used either to evaluate R_{50} ratings for commercial fuels marketed in a given locality or it may be used to develop specifications for different localities or seasons of the year based on some preselected value of R_{50}.

Acceptable values of R_{50} can be established only by surveying marketed fuels to determine the range and average levels. Values of R_{50} were computed for motor fuels marketed in the United States over a three-year period and it has been concluded that a rating of 200 is conservative; a value of 220 or higher is "ultra conservative."

Table 7—Fuel Economy of Premium and Regular Requirement Vehicles

1960 Vehicles	Nominal Fuel Properties		Average Economy at Constant Speed on Level Road At Given MPH, mpg			
	°API	90% Pt, °F	30	40	50	60
Group 1	76	240	21.6	20.1	18.0	16.4
	64	320	22.3	21.2	19.2	17.3
Group 2	69	280	19.8	13.3	16.1	14.5
	66	305	19.1	18.5	16.3	15.0

FUEL ECONOMY AND EVAPORATION LOSSES

There are two volatility factors which, at least theoretically, influence fuel economy attained with a gasoline. First, there is the question of thermal efficiency or miles per gallon. Assuming no evaporation losses, a gallon of high volatility, high API gravity fuel does not contain as much energy as a gallon of low volatility, low gravity fuel. Therefore, at the same energy conversion ratio, it will not carry a vehicle as far. In other words, heavy hydrocarbons give the consumer greater heat content per gallon of fuel and, for this reason, some refiners choose to make full use of such components.

In cars prone to fuel maldistribution, a heavier gasoline may give somewhat poorer mixture distribution and actually be less efficient than a lighter fuel. In practice, there is little difference obtained from various gasolines during normal operation of a vehicle. Results of some tests in a 1956 vehicle showed a 10 percent difference in mileage at 20 miles per hour between two fuels of 67° and 52° API gravity, respectively.[18] Additional data are shown in Table 7 for 1960 premium and regular requirement vehicles equipped with V-8 engines and automatic transmissions.

The first pair of fuels, with gravities of 76° and 64° API, show an average difference in mileage of about 6 percent. These fuels differ in their 90 percent points by 80° F. The second set of gasolines have a range of 3° API gravity and 25° F in 90 percent point. Mileage performance varies only slightly and it would probably be even less for normal stop-and-go driving patterns. Economy differences among most commercial gasolines appear to be in the order of 2 to 6 percent. At best, this is equivalent to slightly over one-half mile per gallon for the average motorist.

In addition to heat content, there is also the problem of actual fuel loss from the fuel tank and from the carburetor because of evaporation. The extent of this loss depends on the amount and type of light hydrocarbons in the gasoline and on air circulation through the storage. Temperature is important but must be considered along with other weather conditions.

Evaporation is expected at high temperatures but wind velocity may be even more important. For example, it has been shown that a 10 psi Reid vapor pressure fuel can be completely evaporated from a carburetor bowl overnight at a temperature of 0° F when a head wind of 30 miles per hour is directed at the car.[18] Such evaporation from the carburetor float bowl results not only in loss of fuel but in a difficult starting problem.

Air movement in and out of the fuel tank is also of prime importance in determining the extent of fuel loss. The results of an evaporation loss test conducted on

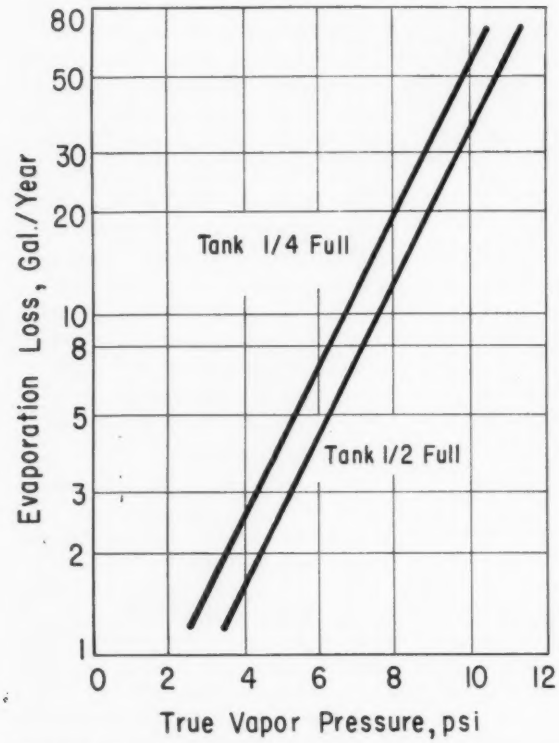


FIGURE 26—Air movement in and out of the fuel tank contributes to fuel loss.

fifteen automobiles are presented in Figure 26.[50] Data are based on year-around average operation. Losses in gallons per year are shown as a function of the true vapor pressure of the gasoline.

The true vapor pressure is determined from the Reid vapor pressure of the fuel and the average ambient air temperature. (See Figure 28, later.) Based on summer gasolines of 8-9 Rvp and winter gasolines of 12-13 Rvp, evaporation losses from the fuel tank appear to be in the order of 2-5 gallons per year. The level of fuel in the tank is also significant since average losses vary from 2.7 gallons per year for a tank kept one-half full to 4.2 gallons per year for a tank one-quarter full.

Carbuertor vapor loss to the atmosphere is largely a function of the arrangement of internal and external vents employed in design. It has been shown[22] that evaporation losses are greatest from externally vented carburetors which either have restricted internal vents or no internal vents. Practically no outside loss occurs when externally vented carburetors are provided with multiple internal vents or single internal vents of at least ¼-inch diameter.

The amount of fuel vapor formed in the carburetor is governed by fuel volatility and the carburetor bowl temperature. Naturally, any vapor formed will represent loss of fuel as far as economy is concerned. With external venting, vapor is lost to the atmosphere and contributes to air pollution. In the case of internal venting only, the air-fuel mixture will be over-rich for optimum operation: If excessively rich, hot starting and idle will suffer.

Results of carburetor loss tests were reported by Holaday and Heath in 1951.[50] Differences in temperature between the carburetor bowl and ambient air were determined for 20 cars. The average temperature rises for various types of driving in both summer and winter are shown in Table 8. Fuel loss at the carburetor for commercial gasolines was reported to be about 0.3 vol. percent, or about 2 gallons per year for the average motorist.

More recent studies have been conducted with 1956-57 cars using various carburetor venting arrangements.[22,103] Fuel volatility, carburetor bowl temperature and driving pattern have pronounced effects on evaporation. On a volume basis, typical loss reported during summer weather run about 2 percent.

Slow-speed driving in traffic tends to increase float bowl temperatures and promote loss. Driving pattern also influences loss by affecting the pressure differential across the external vent. At speeds above about 25 mph, evaporation loss diminishes as a result of increasing relative pressure outside of the float bowl. Hot idle operation is most severe and losses in the order of 5 weight percent are possible. When cruising at low speeds, losses are less than 1 percent.[22] During the "heat soak" period immediately following engine shut-off, additional vapor loss usually occurs. The loss was measured at 0.018 pound (0.003 gal.) of fuel for one car during the first 30 minutes after shutdown at an ambient temperature of 84° F.

Reid vapor pressure by itself is not a satisfactory indication of carburetor loss. The distillation character-

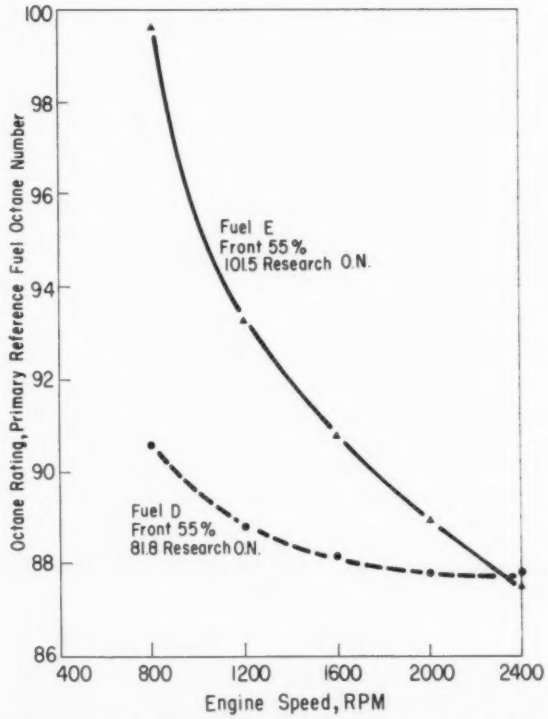


FIGURE 27—Wide open throttle ratings by the Modified Borderline method show the effect of octane distribution within a fuel.

istics that define the light hydrocarbon content of a gasoline are also important. Analyses of vapor lost from the carburetor bowl during car operation on commercial gasolines have been made and are reported in Table 9.

These data represent different fuels, cars and driving conditions, observed during independent studies. Yet, the results are quite similar. In addition to butanes, significant percentages of C_5, C_6 and even C_7^+ hydrocarbons were lost.

Loss in octane quality with the vaporization of light compounds is one facet of vapor loss that has not as yet been mentioned. A loss of 4 vol. percent $C_4 - C_5$ mixture, for example, could lower the Research octane quality of typical premium and regular gasoline by 0.3 and 0.4 numbers, respectively. Corresponding decreases in Motor octane would be about 0.7 number for both premium and regular at current levels of octane quality and tetraethyl lead usage. Such loss could easily make the difference between satisfying or not satisfying the octane appetite of critical cars. This is particularly true for part-throttle or high-speed operation, where Motor octane quality is of prime importance.

CRANKCASE OIL DILUTION

Crankcase oil dilution results primarily from heavy boiling components in a gasoline. Lubricant is washed from the cylinder walls whenever gasoline reaches the cylinders in liquid form and works its way past the piston rings into the crankcase.

All engines accumulate some gasoline in the crankcase, especially when frequent cold starts are made. In cold weather, excess fuel supplied by the choke only partially vaporizes and the liquid portion finds its way into the cylinders. Ambient temperature, air-fuel ratios, frequency of oil drains and mechanical condition of the engine directly influence the amount of dilution.

Before advent of the automotic choke and other engine improvements, dilution ranged as high as 15-20 percent during the winter. Today, dilution seldom exceeds 5 percent of the volume of oil in the crankcase. Heavy duty equipment and farm tractors are a greater problem in this respect than are passenger cars.

TABLE 8—Temperature of Fuel in Carburetor Bowl Minus Ambient Temperature

Season	AVERAGE TEMPERATURE RISE		
	City Traffic	Highway Driving	
		30 mph	50 mph
Summer	30	28	27
Winter	38	28	26

TABLE 9—Analysis of Vented Vapor

Fuel	Premium[103]	Summer-Grade[22]	
Type of Driving	....	15 mph	Hot Idle
Hydrocarbon, Wt. %			
Propane	2	1.0	1.2
Butanes	43	30.5	26.8
Butenes	1	....	....
Pentanes	33	33.4	32.5
Pentenes	....	11.4	11.5
Hexanes	11	11.4	12.8
Hexenes	3	2.6	3.0
C_7+	7	9.7	12.2
Total Loss	100	100	100
Loss, Wt. % of whole	0.74	....	....

General effects of fuel volatility and ambient temperature on the extent of oil dilution in passenger cars and trucks have been studied.[50] Average dilution in this particular test program varied from a little over 1 percent in the summer to 3 percent in the winter. Dilution increased about 1 percent for each 25° F drop in atmospheric temperature. In addition, a 50° F increase in the 90 percent point of a gasoline increased average dilution to about 3 percent in the summer and 7½ percent in the winter.

The condensation of unburned fuel vapors in the crankcase may also contribute to dilution. With excessive dilution, viscosity of the oil is reduced and decomposition hastened. Poor lubrication, increased engine wear and formation of varnish may result.

ENGINE CLEANLINESS

The question of over-all engine cleanliness is also a function of the heavier hydrocarbons present in a fuel. High-boiling aromatics, for example, while offering excellent antiknock quality, long have been blamed for combustion chamber deposits.[59, 104] Recent tests of engine deposition using radio-actively "tagged" fuel components also point to heavy aromatics.[87]

The effect of engine deposits on octane requirement increase, while significant, is not directly related in current vehicles to volatility control. The adoption of overhead valve combustion chambers with their greater breathing characteristics and the increase in compression ratios with greater deposit burning have greatly reduced the effect of deposits with respect to octane requirement increase. Deposits from aromatic fuel components are still a problem from the standpoint of surface ignition.

One phenomenon of surface ignition which is associated with high-compression cars is engine "rumble." This low-frequency noise, related to vibration of the crankshaft,[90] becomes more of a problem as compression ratio is raised above 9.5:1. Changes in engine design promise no ready solution for rumble. Tests have shown rumble to be particularly susceptible to inducement by heavy aromatics.[34] Both surface ignition and rumble may be alleviated by phosphorus fuel additives which control and modify deposits.

Spark plug fouling is also a problem in general engine cleanliness which may become more serious as engine-power to vehicle-weight ratios increase. The heavy portion of the fuel is again important with regard to plug deposits and fouling. Much assistance can be obtained through the use of additives and/or chamber and spark plug design.

OCTANE MALDISTRIBUTION

The topic of antiknock behavior of fuels on the road and its relation to fuel volatility is an increasingly important problem. This is especially true for cars prone to fuel segregation or maldistribution at low engine speeds. Vehicles equipped with manual transmissions (i.e., foreign and compact cars) are particularly susceptible to segregation since engine loading is possible at low speeds. In this case, proper distribution of octane quality in a fuel's boiling range is very important.

The phenomenon of maldistribution exists in certain cars at low manifold velocities when the heavy, high octane components of a fuel lag the lower octane light hydrocarbons in reaching the cylinders. The heavier

portions of a fuel tend to adhere to the manifold walls during the initial moments of acceleration. When this happens, antiknock performance of the fuel depends primarily on the octane quality of light hydrocarbons reaching the cylinders.

The road behavior[20] of two gasolines of similar whole-fuel laboratory octane quality but with widely different front-end octane characteristics is shown in Figure 27. The fuel whose front 55 percent is of low quality rates as much as 10 octane numbers less than its companion blend at low engine speeds. In those instances of maldistribution, the octane quality of the volatile portion of a gasoline becomes a controlling factor for customer antiknock satisfaction.

Goals for Volatility Blending

In using the above information to set controls for motor fuel volatility, it is convenient to consider car performance in relation to the front-, mid-, and back-portion of the distillation curve.

FRONT-END VOLATILITY

The front-end is the most difficult boiling-range to control and it also is of the greatest economic significance. Economic advantage from using maximum light ends must be balanced against car performance. Both vapor formation and cold starting depend primarily on front-end quality. During hot weather, volatility is limited by temperature. In cold weather, volatility is limited by legal vapor pressure restrictions, maximum temperatures that may promote vapor lock, and evaporation losses. Usually, excess light ends are available, but if in short supply, sufficient volatility should be maintained for satisfactory starting at the lowest ambient temperatures.

It has been pointed out that there is less flexibility in fuel volatility control for maximum than for minimum ambient temperatures. Therefore, vapor lock control may be necessary at the expense of some cold starting complaints. The difficulty is lessened by the fact that cold starting is not a serious problem because of fuel until temperatures drop to near 0° F. The greatest control problem exists during intermediate seasons when unseasonable weather is most likely to occur.

It is impossible to cite specific volatility limits for vapor lock control because of the interdependency of Rvp and distillation characteristics. The relationship between these qualities varies for each blending situation, and depends on the base stocks and pressurizing agents employed. The most acceptable approach is to evaluate gasolines using one or more of the control methods detailed previously.

Cold starting control for best performance in late-model cars is obtained at 40-50° F ambient by specifying a minimum of 20 percent of fuel evaporated at 158° F with a range in Rvp of 10-11 psi. As ambient temperatures fall to 0° F, the percent of fuel distilled at 158° F should be increased to 30-35 percent. In this case, Rvp should range from 12.5 to 13.5 psi.

Evaporation loss also influences specifications set in the refinery. It has been stated that 5° F can be added to the design temperature for vapor lock to compensate for loss of light ends during shipment and storage.[24]

MID-RANGE VOLATILITY

The problems primarily controlled by the 50 percent range are warm-up, acceleration after warm-up, and carburetor icing. Extensive tests including 1959 model cars have indicated that good warm-up performance at ambient temperatures near 0° F requires a maximum 50 percent point between 210-220° F; a 200° F mid-point seems ideal. Mid-volatility is still important at ambient temperatures of 50° F, where one study indicates a maximum 50 percent point of 240° F for good performance.

Acceleration is not impaired except in cases of heavy fuels—and may be controlled by keeping the 50 percent point below 250° F.

The tendency for a fuel to "ice" is greatly reduced even in those engines susceptible to the problem, by maintaining a minimum 50 percent point of at least 240° F. Since this temperature would cause poor warm-up behavior under some temperature conditions, it may be necessary to use anti-icing additives to help solve the problem.

Vapor handling problems are also affected by the 50 percent point—depending upon the particular pressurizing agent used. For example, blending pentane will alter the mid-range of the fuel much more than butane. Close control of mid-range with respect to type of pressurizing agent may be necessary, particularly in the spring and fall of the year.

BACK-END VOLATILITY

Back-end volatility is the least sharply defined range in the distillation curve. The 90 percent point mainly affects oil dilution, engine cleanliness and Btu content. It has secondary importance in control of warm-up and acceleration. All of these problems, with the exception of Btu content, suggest a 90 percent point as low as possible. With regard to engine cleanliness, both thermally and catalytically cracked fuels having 90 percent points in excess of 330° F have been reported deleterious.[50] The 90 percent temperature also can be related to 50 percent temperature and performance under warm-up and accelerating conditions. From a performance standpoint alone, a 90 percent point of 300-315° F appears ideal. Marketed fuels average somewhat higher in 90 percent temperature—325° F for premiums and 342° F for regulars.

How to Predict Gasoline Blends

When allocating refinery components to meet motor fuel specifications, there are a number of useful calculation procedures for predicting final blends. These procedures may be used for premium and regular grade formulation with current stocks to achieve desired product quality. They also facilitate refinery economic studies and help establish needs for future product requirements.

Most important gasoline specifications are for volatility and antiknock quality. One of these qualities cannot be evaluated realistically without consideration of the other. Therefore, it is frequently necessary to be able to combine refinery streams, including light ends, on paper to predict at least approximate qualities. Such calculations are usually confirmed by laboratory blends and small adjustments are made when necessary.

A fairly accurate prediction of fuel properties normally can be made for current blending stocks in a given refinery by using a correction factor based on past experience. However, more accurate calculation methods may be required for future product planning, particularly when new components are being tested in the blending scheme.

Modern techniques in refinery technology solve complex refinery problems involving many base stocks, products and control variables by linear programming on electronic computers. This has eliminated much of the laborious hand calculation from blending optimization problems. Yet, the dependability of results, whether attained by slide rule or computer, depends on ability to properly equate the problem to meet desired specifications. Linear programming itself imposes an additional restriction; that is, all blending equations must be expressed as linear relationships.

The real difficulties in blending calculations generally stem from one or more of the following:

- Shortcomings in common laboratory tests
- Deviations from ideal solution behavior
- Lack of a basic understanding of those laws governing blending behavior.

The shortcomings of laboratory tests in view of basic theories for blending will be discussed later. Some blending difficulties are caused by the fact that most solutions of petroleum hydrocarbons do not behave ideally. An ideal solution is one in which there are no specific forces of attraction or repulsion acting between the components to cause a change in molecular environment from the pure or unblended state. In order for a solution to behave ideally, the molecules of the components must be very similar in size, shape and other properties. Since this is seldom the case in gasoline blending, such properties as solution volume, vapor pressure, distillation and others are affected and, therefore, are not strictly additive. The more dissimilar the components, the greater will be the variation from ideal behavior. *For this reason, most difficulty in predicting volatility is encountered when combining light ends with full-boiling stocks.*

Except for deviations from ideal solutions, the theoretical bases for calculation of Rvp and distillation are exact, but generally too involved to be practical. In developing easy-to-handle, short-cut methods of blending (e.g., so-called "blending numbers") computation is more of an art than a science. In the case of octane quality, the fundamental laws governing blending action are obscure, and for close accuracy, empirical methods of prediction are used.

BLENDING FOR VOLATILITY

Reid Vapor Pressure. The vapor pressure of hydrocarbon mixtures can be computed by summing, for all components, the products of their respective percentage in the blend times their vapor pressure. This calculation is based on Raoult's law for partial pressure according to the expression:

$$p_t = p_1x_1 + p_2x_2 + \cdots + p_nx_n$$

where

p_t = vapor pressure of blend
$p_1, p_2 \cdots p_n$ = vapor pressure of individual components
$x_1, x_2 \cdots x_n$ = respective mol fractions of components

The calculation is complicated by the fact that: (a) true, rather than Reid, vapor pressures must be used, and (b) component fractions must be expressed as mol percent. Since ideal solution behavior is assumed, a slight inaccuracy is introduced.

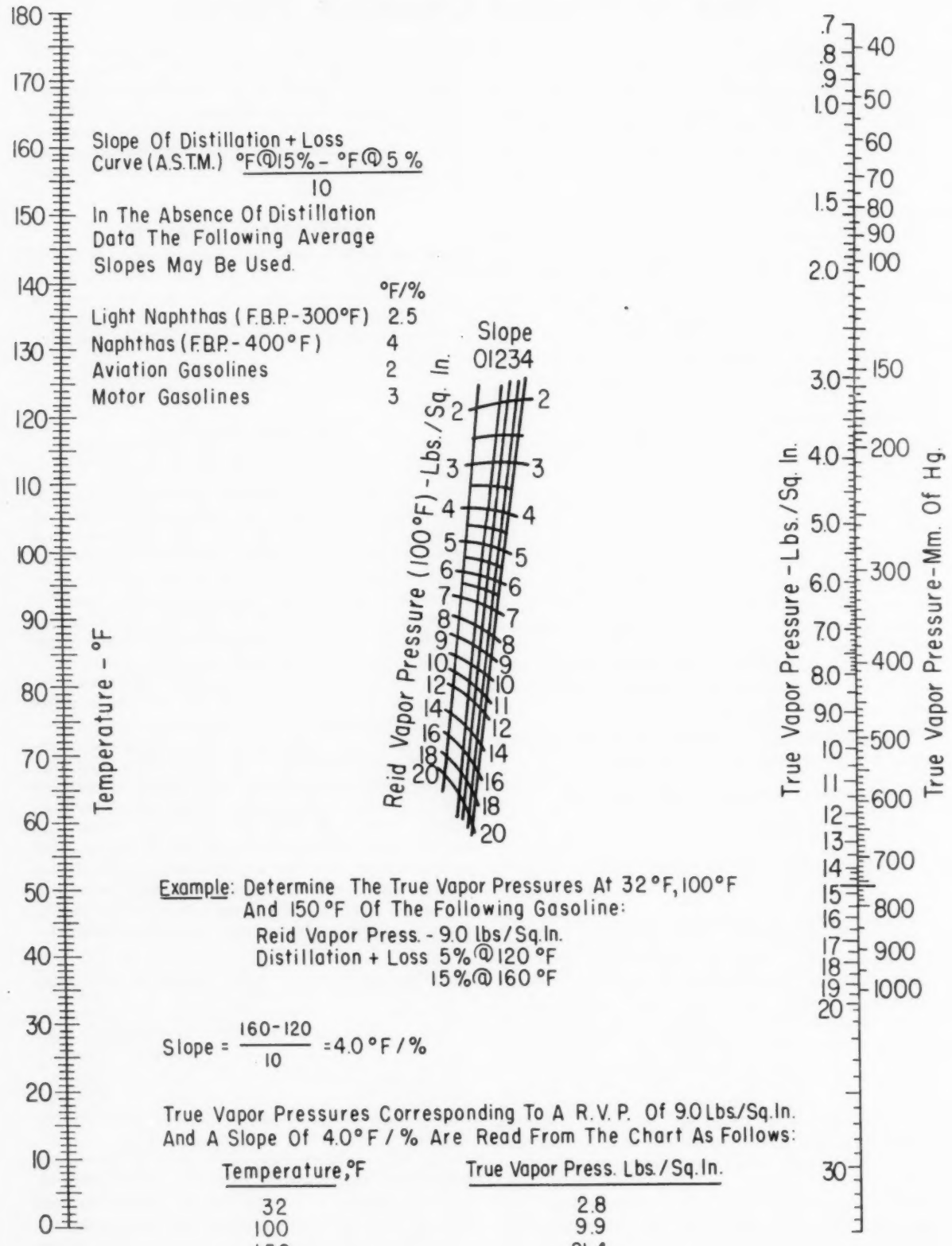
Various tests for vapor pressure have been offered,[16, 67] including an accurate method for quick determination of true vapor pressure in the laboratory.[97] However, the Reid method is the accepted test in the refinery. For most blending components, empirical correlations between Reid and true vapor pressure are used to determine proper values of p_1, p_2, etc.

The true vapor pressure is always higher than the value recorded in the Reid test. This is so because equilibrium pressure between the gas and liquid phases in the Reid bomb is attained by evaporation of the most volatile components from the fuel sample. Those light hydrocarbons that evaporate and fill the vapor space in the test apparatus are not measured as contributing to the vapor pressure of the liquid at the time of test. The ratio of true to Reid vapor pressure for various types of volatile stocks may vary as shown in Table 10.[70]

TABLE 10—Ratio of True Vapor Pressure to Reid Vapor Pressure

Stocks	True v.p./Reid v.p.	
	Average	Range
Hydrocarbons, bottle gas, etc.	1.40	1.17—1.6
Natural gasolines	1.09	1.03—1.14
Gasolines	1.07	1.03—1.45

Approximate ratios between the true and Reid vapor pressures of many gasolines have been presented by Nelson.[70] A number of correlations have been developed relating the two types of vapor pressure measurement.[21, 61, 99] One such correlation is shown in Figure 28.[61] This relation, based on data developed by the CRC,[21] uses a factor in addition to Rvp—the slope of


Slope Of Distillation + Loss Curve (A.S.T.M.) °F@15% - °F@5%
10
In The Absence Of Distillation Data The Following Average Slopes May Be Used.
°F/%
Light Naphthas (F.B.P.-300°F) 2.5
Naphthas (F.B.P.-400°F) 4
Aviation Gasolines 2
Motor Gasolines 3
Slope
01234
Reid Vapor Pressure (100°F) - Lbs./Sq. In.
Temperature - °F
True Vapor Pressure - Lbs./Sq. In.
True Vapor Pressure - Mm. Of Hg.

Example: Determine The True Vapor Pressures At 32°F, 100°F And 150°F Of The Following Gasoline:

Reid Vapor Press. - 9.0 lbs/Sq.In.
Distillation + Loss 5%@120°F
15%@160°F

$$\text{Slope} = \frac{160-120}{10} = 4.0\,°F/\%$$

True Vapor Pressures Corresponding To A R.V.P. Of 9.0 Lbs/Sq.In. And A Slope Of 4.0°F/% Are Read From The Chart As Follows:

Temperature, °F	True Vapor Press. Lbs./Sq.In.
32	2.8
100	9.9
150	21.4

FIGURE 28—Use this chart to get true vapor pressure.

the ASTM distillation curve at the 10 percent point. True vapor pressure also has been related to the 50 percent point of various stocks.[68]

To convert from volume to mol percent basis, it is necessary to establish molecular weights for components. Such data for wide-boiling materials can be estimated by empirical relationships such as developed by Winn[106] (see Figure 29). Molecular weight is correlated with the commonly available properties of specific gravity and mean average boiling point. The mean average boiling point is determined from ASTM distillation data for any stock.[101,106] The molecular weight and specific gravity of paraffinic hydrocarbons also are correlated.[81] For light hydrocarbons used in pressurizing, vapor pressure and molecular weight data are shown in Table 11.

The rigorous method just described is frequently abbreviated by averaging Reid vapor pressure on a mol percent basis. This eliminates the need for converting back and forth between Reid and true vapor pressure. This approach also removes a possible source of error due to inaccuracies in the correlation of two vapor pressure measurements. Even the use of mol fractions is not much more accurate than direct volumetric averaging of Rvp values. This is particularly true for blends of full-boiling stocks. The method of volume averaging of Rvp has also been found applicable to blends with natural gasoline or with pentane fractions.[41] However, the results of such calculations are often low when blending volatile hydrocarbons and invariably low for blends containing a butane fraction.

The difficulty is overcome with Rvp "blending values" developed for narrow-boiling stocks, especially light fractions. These values are substituted for Rvp in the volumetric method of calculation. Such blending numbers are usually satisfactory for the particular blending system for which they are developed. A disadvantage is that these values tend to vary with both the boiling-range distribution and concentration of base stocks used.

Reid blending numbers developed for 15 percent *n*-butane and 30 percent isopentane individually in three refinery stocks are shown in Table 12.[35] These values have found wide application for blending fairly pure *n*-butane or isopentane streams.

The vapor pressures of light refinery components will vary, of course, depending on the concentration of different hydrocarbons present. For example, a C_4 stream may range in true vapor pressures from 52 to 71 psi, depending on the relative proportions of *n*-butane, *i*-butane, and butylenes. Any C_3 and C_5 hydrocarbons present also have an effect. Blending values of C_4 mixtures containing various ratios of iso and *n*-butane are shown in Figure 30.[41]

Accuracy is stated in the order of 0.2 psi when predicting Rvp using these values. This vapor pressure relationship has been applied to the solution of gasoline blending problems using linear programming.[26] Techniques of regression analysis using electronic computers facilitate derivation of blending Rvp's for each component in a given refinery situation. Blending Rvp values for a large number of gasoline components have been developed in connection with recent unpublished studies.

Additional information for blending to vapor pressure is given by Nelson.[68] The percent butanes (62 psia) required to attain given true vapor pressures is related to the mid-boiling point of various stocks. *A rough estimate, often used for blending control, is that the addition of 1 percent butanes increases the vapor pressure of a fuel by 0.7 to 0.9 psia.*

A new method for computing the Rvp requirements of blends has been described recently by Stewart.[92] Allowance is made for both partial vaporization of the sample in the Reid bomb and for deviations from ideal gas behavior. Calculations are based on the expression:

$$\Sigma \frac{Vi\rho mi}{F + Hp_i\gamma i} \rightleftharpoons (\gamma_i p_i^\circ - p^\circ) = 0$$

where

Vi = volume fraction of component i
ρmi = molar density of compoent i (lb-moles per bbl)
F = lb-moles of component i per bbl liquid blend
H = coefficient for flash vaporization
p_i° = reference value of ideal equilibrium constant at zero blend Rvp
p° = value of p_i for blend as a component for further blending
γi = activity coefficient for component i

All quantities in this equation are given or obtainable from tabulated data except γi and F. The amount of component i required (Vi) is computed by trial-and-error solution with assumed values of F. The method is quite accurate, but is complicated for hand calculation if more than two components are involved.

Stewart also has compared the accuracy of various methods for predicting Reid vapor pressures of blends.[92] This comparison for 67 fuels is presented in Table 13. Method 5 is the one described immediately above. Based on the deviations from observed Rvp, the methods differ according to decreasing accuracy as: No. 1, 5, 3, 4 and 2.

Distillation. Distillation characteristics of blends can be determined from respective distillation data for component stocks. The two standard types of laboratory distillations for characterizing petroleum stocks are the ASTM and true-boiling-point (TBP) methods. The ASTM distillation is universally used for refinery control. Since it is essentially non-fractionating, adjacent cuts from the ASTM distillation overlap considerably and contain many hydrocarbons in common.

In contrast, the TBP distillation is precise and separates individual compounds in order of increasing boiling-point. There is practically no overlapping of adjacent cuts. As a result, boiling points of fuels taken from a TBP curve are additive while those taken from the ASTM curve are not.

A composite TBP curve is obtained by averaging the percent distilled at selected temperatures for respective stocks according to their volume fractions in a blend. Since TBP data are seldom available for blending components, calculation by this method is based on correlations between ASTM and TBP curves. Typical results from these two distillations are illustrated in Figure 31 for a full-boiling petroleum fraction. The two curves have essentially the same shape, but the TBP curve has a greater slope.

The comparison shown is similar for all stocks even though exact differences in slope and the point of intersection for the two curves will vary with the boiling characteristics of the fraction. At good deal of work has

been done over the years by various investigators to develop empirical correlation between these analytical distillations.[31, 39, 73, 74, 100]

Based on laboratory work plus available data in the literature through 1941, Edmister and Pollock[32] related the 50 percent evaporated temperatures of the TBP and ASTM curves, as shown in Figure 32. The average deviation for this correlation is reported to be about 7° F. For stocks boiling in the gasoline range, the TBP curve crosses the ASTM curve above the 50 percent point. Figure 33 presents a correlation of TBP slope with ASTM slope for corresponding segments of the distillation curve.[32] For this purpose, the curve between 10 and 90 percent evaporated was divided into 20 percent segments. The average deviation of predicting the 30 percent point using this relation is about 0.7° F—that for the 70 percent point about 0.8° F.

The correlations given in Figures 32 and 33 permit conversion of ASTM data to TBP data by first determining the TBP 50 percent point. Then, the temperature ranges of various segments of the TBP curve determined from the slope relations are successively added to (above TBP 50 percent) or substracted from (below TBP 50 percent) this temperature. These TBP data for base components are averaged volunmetrically to obtain the blend curve. The procedure is reversed to convert the resulting TBP curve for the blend back to an ASTM basis. The calculations involved have been detailed by Kersten.[51] In this method, essentially pure compounds such as butanes or pentanes are considered 100 percent evaporated at temperatures above their boiling points.

Theoretically, calculation of a blend distillation curve using TBP data will provide greater accuracy than a similar determination using ASTM curves of the components. Yet, for many blending systems, the additional work entailed in the TBP technique is hard to justify on the basis of the small increase in accuracy. Satisfactory results are generally obtained by estimating directly from the ASTM curve of base stocks. Only small adjustments in final blending are required, particularly if full-boiling components are involved.

Largest deviations from the calculated curve will occur when the blend includes several components and narrow-boiling range stocks. Deviations become greater as the percentage of any narrow-boiling component increases, or as the number of these stocks increases.

The most difficulty is encountered when pressurizing for finished blends with butanes, pentanes or natural gasolines. In these cases, the front portion of the distillation curve is apt to be in error. For the heavier portion of a blend (over 30 percent evaporated), deviations from the calculated curve using ASTM data seldom is greater than 4-5° F at a given percent point. This observation is based on results with many blends and seems to be true regardless of the pressurizing agent.

One convenient method of handling distillation calculations is by use of blending numbers. These are developed for the component in a given refinery situation since values change for different blending schemes. Distillation blending values for two light components in a number of different base stocks are shown in Figure 34. Inspection data on the base stocks are given in Table 14.

At any given temperature, the blending value of a stock is weighted according to its volume concentration in a blend. Normal butane and isopentane are shown to behave similarly in their effects on blend vola-

Here's how Fuels

VOLATILITY control in the refinery is commonly judged by two distinct tests—vapor pressure and distillation. Considerable work has been done to relate these and other laboratory test results to the performance of gasoline on the road. Test methods which are used for volatility control are summarized in the accompanying table.

Vapor Pressure. The Reid test for vapor pressure is well known and universally used throughout the industry. However, this test by itself is not adequate to determine vapor forming characteristics in a gasoline engine. Reid vapor pressure only measures the effects of the lightest hydrocarbons. It depends particularly on the relative concentrations of hydrocarbons boiling up to 100° F. The Reid test conditions of temperature (100° F) and vapor-liquid ratio (4-to-1) do not represent conditions in a car's fuel system. Under operating conditions in a vehicle, the actual amount of vapor formed also depends on the front-end of the distillation curve. Effective volatility control is possible when Rvp is used in conjunction with the front-end distillation of a fuel.

The General Motors vapor pressure (GMvp) is a modification of the Reid method.[16] It has been developed to provide a better measure, with a single test, of vapor formation as encountered in vehicle fuel systems. A vapor-liquid ratio of 25-to-1 is used, rather than the 4-to-1 ratio employed in the Reid test.

In addition to the above methods, test apparatus has been developed which measures the vapor pressure of a gasoline about three times as fast as the Reid method using only about 1 ml of sample.[67] This "micro" test has been designed for a vapor-liquid ratio of 4-to-1; however, any desired ratio may be used by merely changing the sample size. An empirical equation relates micro vapor pressure to the Reid test.

Distillation. The aspects of engine operation related to fuel volatility can also be related directly to the ASTM distillation test method. Volatility problems can be controlled to a large extent by attention to either the front-, mid-, or back-portion of the distillation curve. Usually the 10, 50 and 90 percent points are selected for correlation. However, other distillation points have been used for volatility control; e.g., the percent evaporated at 158° F. The initial (IBP) and end (EP) points of the test are difficult to reproduce but do give some indication of light and heavy ends present. Distillation loss is often included as one of the items in specifications for motor gasolines. As such, it limits the amount of light hydrocarbons present in a fuel.

Vapor Forming Characteristics. It is apparent that a test method having the ability to measure directly the vapor forming characteristics of a finished motor fuel under conditions of use is desirable. Two methods are generally available, but they have an inherent lack of simplicity.

The CRC procedure[6, 33] consists of a graduated burette, immersed in a bath so that a desired temperature can be achieved. The bottom of the burette is connected to a mercury manometer and leveling tube. A sample of liquid gasoline of known volume is introduced into the burette and the pressure on the burette is maintained at atmospheric pressure. By adjustment of the bath temperature, the gasoline sample is caused to vaporize. Readings are taken to determine the temperature and the volume of vapor in the burette when

tility; i.e., both exhibit a large "carry-over" effect. Isopentane, however, has a depressing effect on the initial portion of the curve below distillation temperatures from 120° to 160° F. Also, only at temperatures of 230° F or above do these compounds assume values corresponding to 100-percent evaporation.

The concentrations of butane and pentane in Figure 34 are fairly high and are considered to represent maximum practical percentages. The base stocks employed are the same for both agents. Blending values for *n*-butane and isopentane vary greatly, depending on the particular base stock used. In addition, Figure 34 illus-

Are Tested for Volatility

equilibrium has been attained after each adjustment. A curve relating temperature to vapor-liquid ratio is plotted (Temperature-V/L curve).[1]

The Sunbury apparatus, developed in England, provides a second method for determining temperature—V/L characteristics.[40, 85] This test is similar to the CRC method. It consists essentially of a graduated burette fitted with a temperature-controlled bath and a means of keeping the sample under constant agitation.

This apparatus appears to be of more compact design and easier to operate than the CRC equipment. In addition, it is reported to have the following advantages over the CRC method:

- Better accuracy
- Less time to attain desired temperatures
- More rapid dispersion of vapors in the burette.

Experimental data have shown the repeatability and reproducibility of this method to be ±0.5 and ±1.0° F, respectively, at vapor-liquid ratios between 10 and 40.

Test Identity	Designation	Reference	Purpose
Reid Vapor Pressure (Rvp)	ASTM D-323	5, 88	Defines the vapor pressure of motor fuel and natural gasoline at a temperature of 100° F and a vapor-liquid ratio of 4-to-1. For natural gasolines over 26 psi, special procedures are used.
GM Vapor Pressure (GMvp)	General Motors	16	Defines the vapor pressure of finished motor fuel at a vapor-liquid ratio of 25-to-1. Otherwise identical to Reid method.
Micro Vapor Pressure	Esso	67	Defines the vapor pressure of gasoline rapidly with a very small sample (1 ml). Vapor-liquid ratio is variable but designed for use mainly at 4-to-1. Results are empirically related to Reid vapor pressure.
Distillation	ASTM D-86	5, 88	A non-fractionating type of distillation in which hydrocarbons are collected as successively higher boiling mixtures. A boiling-point profile results. Used for finished gasoline, naphtha, kerosine and related products.
Distillation	ASTM D-216-40	5, 88, 96	Same as ASTM-D-86 except applies to natural gasoline and thus provides for measurement at low temperatures. NGAA Standard addition calls for readings in accordance with NGAA specifications of % evap. at 140 and 275° F.
Distillation	ASTM D-158	5, 88	Proposed. Same as ASTM D-86 except would expand test to cover gas oil and distillates.
Low-Temperature Fractional Analysis	Podbielniak	2, 72, 75, 76	A method of precise fractional distillation. Components of a fuel are separated in order of boiling point and identified. Percent of each hydrocarbon is determined.
Gas Chromotography	Various	38, 42, 66, 86	Separates components of a gasoline by selective adsorption according to molecular weight. Accurately determines the composition of natural-gas liquids, refinery streams and lighter portions of finished gasolines.
Temperature-Vapor/Liquid Ratio	CRC	1, 6, 33	Measures the volume of vapor formed per volume of liquid fuel at given conditions of pressure and temperature. Directly indicates the vapor tendency of gasoline in vehicle fuel systems.
Temperature-Vapor/Liquid Ratio	Sunbury	11, 40, 85	Same as CRC method except for differences in apparatus and test procedure.
Crankcase Oil Dilution	ASTM D-322-58T	5	Determines the amount of gasoline dilution in crankcase oils of automotive engines. Applicable for dilutions up to 20 percent. Allows simultaneous determination of water present.
Research Octane Number	ASTM D-908	3, 4	Determines antiknock quality of a fuel under relatively mild engine conditions. Ratings of volatile products used for pressurizing are difficult to obtain due to premature vaporization in the fuel system. A method of carburetor cooling is provided for testing volatile fuels.
Motor Octane Number	ASTM D-357	3, 4	Determines antiknock quality under more severe engine conditions. Comments pertaining to volatile fuels are the same as for research octane number method.

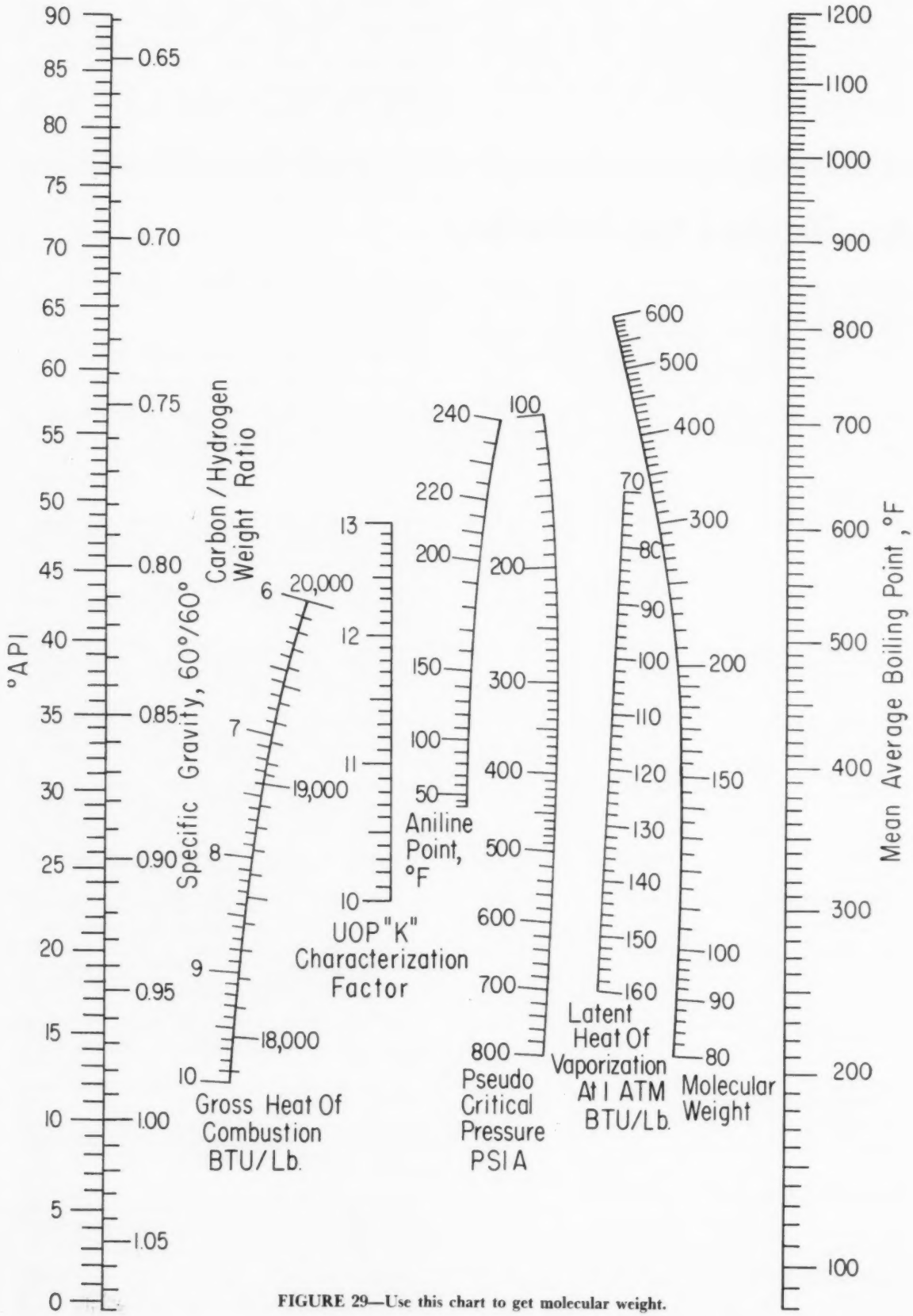

°API
Specific Gravity, 60°/60°
Carbon / Hydrogen Weight Ratio
Gross Heat Of Combustion BTU/Lb.
UOP "K" Characterization Factor
Aniline Point, °F
Pseudo Critical Pressure PSIA
Latent Heat Of Vaporization At 1 ATM BTU/Lb.
Molecular Weight
Mean Average Boiling Point, °F

FIGURE 29—Use this chart to get molecular weight.

TABLE 11—Physical Properties of Volatile Hydrocarbons

HYDROCARBON	Molec. Weight	Boiling Pt., °F @ 14.7 psia	Melting Pt., °F	Vapor Press. psia @ 100° F	LIQUID DENSITY			VAPOR DENSITY, (60° F @ 14.7 psia)			HEAT OF COMBUSTION			
											GROSS		NET	
					Sp. Gr. 60/60° F	Deg API @ 60° F	Lb./gal. @ 60° F	Sp. Gr. (Air = 1.0)	Lb./M Cu. Ft.	Cu. Ft. Gas/gal. Liq.	Btu/Lb.	Btu/cu. Ft.	Btu/Lb.	Btu/cu. Ft.
Saturates														
Propane	44.1	—44	—306	188.7	0.508	147.0	4.23	1.522	116.2	36.5	21,660	2,590	19,950	2,385
n-Butane	58.1	31	—217	52.0	0.584	110.8	4.87	2.006	153.1	31.8	21,310	3,370	19,680	3,118
iso-Butane (2-Methylpropane)	58.1	11	—255	71.0	0.563	119.8	4.69	2.006	153.1	30.7	21,260	3,363	19,630	3,105
n-Pentane	72.1	97	—201	15.6	0.631	92.7	5.26	2.491	190.1	27.7	21,090	4,016	19,520	3,722
iso-Pentane (2-Methylbutane)	72.1	82	—256	20.4	0.625	94.9	5.21	2.491	190.1	27.4	21,025	4,008	19,480	3,716
neo-Pentane (2, 2-Dimethylpropane)	72.1	49	+ 2	38.0	0.601	103.9	5.01	2.491	190.1	26.3	20,970	3,993	19,400	3,693
Unsaturates														
Propylene (Propene)	42.1	—54	—301	221	0.522	139.6	4.35	1.451	111.0	39.2	21,040	2,336	19,690	2,186
iso-Butylene (2-Methylpropene)	56.1	20	—221	63	0.600	104.3	5.00	1.934	148.0	33.8	20,730	3,068	19,380	2,869
d-Butylene (1-Butene)	56.1	21	—302	62	0.601	103.9	5.01	1.934	148.0	33.8	20,840	3,084	19,500	2,885
B-Butylene (2-Butene)	56.1	34	—197	51	0.616	98.3	5.13	2.004	153.3	33.4	20,480	3,140	.....	.....
n-Amylene (1-Pentene)	70.1	11	—265	16	0.646	87.5	5.39	2.420	185.1	29.1	20,710	3,836	19,360	3,586
n-Amylene (2-Pentene)	70.1	98	—265	.....	0.651	85.9	5.42	2.420	185.1	.....	20,401	3,776	.....	.....
2-Methyl-2-Butene	70.1	101.3	—208	.....	0.662	82.2	5.51	2.420	185.1	.....	20,432	3,782	.....	.....

trates how the blending behavior of isopentane changes with concentration from 10 to 30 percent. The base stocks represented in this case are two, similar full-boiling reformates. The blending effects appear to vary significantly with concentration.

Blending numbers such as shown in these figures for *n*-butane and isopentane might be used in conjunction with direct ASTM data for full-boiling stocks to improve prediction accuracy for the front portion of the curve. As with vapor pressure, regression analysis also facilitates derivation of distillation blending values for all components in a blending scheme, regardless of boiling-range. Data so obtained from multi-component, commercial-type blends have yielded blending effects for butane and pentane similar to those shown in Figure 34. Full-range stocks generally blend close to their observed ASTM curves while heavy, flat-boiling stocks (e.g., heavy reformate, aromatics, etc.) act as if they have extra low and even negative percents evaporated at the lower distillation temperatures.

Initial and end points of a distillation are not generally used as a measure of a fuel's volatility performance, although limits are often imposed in specifications. ASTM end point has been related to cut points for other types of distillatio.. (including TBP) by Nelson.[73] The end point of a gasoline blend is frequently much higher than would be expected from the end points of its components.

A method for accurately predicting the ASTM end point of blended hydrocarbons has been reported.[89] The correlations used depend on differences in the observed end points of stocks in a blend, the temperature difference between the end point and 90 percent point of the heavier stock, and the concentration of stocks in the finished blend. The system is adaptable to the combination of two stocks. Multicomponent fuels are treated as a series of binary blends. The standard error of prediction is in the range of 5.6° F. This is excellent in view of the accuracy of a single ASTM end point, which was about 4.8° F in this study.

Regarding pressurizing agents, it was found that addition of from 0 to 15 percent butanes decreases the end point 0.25° F for each percent blended. Similarly, the addition of from 0 to 50 percent pentanes decreases end point 0.28° F for each percent blended.

It is obvious that close correlation exists between

TABLE 12—Reid Vapor Pressure Blending Numbers

Base Stock	Rvp of Base Stock	Rvp Blending Numbers	
		n-Butane (Technical)	Isopentane (Commercial)
HF Alkylate	5.9	59.4	22.0
Cat Naphtha	7.1	58.8	20.7
Cat Reformate	7.8	59.1	20.6
Average		59.1	21.1

TABLE 13—Comparison of Methods for Prediction of Blend Reid Vapor Pressures

Deviation	RVP MINUS PREDICTED RVP BY GIVEN METHOD, psi				
	Recommended Method (P Method)	Method 2 (Volumetric Avg. Rvp)	Method 3 (Haskell and Beavon)[8]	Method 4 (Molar Avg. Rvp)	Method 5 (Molar Avg. P as Charged
BUTANES IN GASOLINE BASE STOCKS (36 BLENDS)					
Average	—0.07	0.61	—0.18	—1.00	—0.39
Standard	0.84	0.98	0.72	1.39	0.95
CASINGHEAD IN GASOLINE BASE STOCKS (12 BLENDS)					
Average	—0.29	0.14	0.14	—0.50	—0.37
Standard	0.42	0.35	0.35	0.59	0.48
n-BUTANE IN LIGHT FLUID GASOLINE AND CATALYTIC REFORMATE (12 BLENDS)					
Average	0.76	1.20	0.67	0.15	0.55
Standard	0.96	1.39	0.79	0.44	0.76
BUTANES AND CASINGHEAD IN CRUDES (7 BLENDS)					
Average	—0.15	2.59	2.25	—1.35	—0.71
Standard	0.26	2.80	2.42	1.49	0.98
ALL DATA (67 BLENDS)					
Average	0.03	0.84	0.28	—0.74	—0.25
Standard	0.76	1.30	1.01	1.17	0.83

Deviations were computed as observed Rvp minus Predicted Rvp, in pounds.

TABLE 14—Boiling Range of Base Stocks

	INSPECTION OF BASE STOCK			
	Cat. Naphtha	Alky.	Reformate A	Reformate B
ASTM Distill., °F				
IBP	100	107	95	103
10% Evap.	122	164	148	151
30	168	195	200	215
50	220	210	238	251
70	287	220	267	279
90	356	242	309	331
EP	411	337	370	407
Rvp, psi	7.1	5.9	7.8	7.8

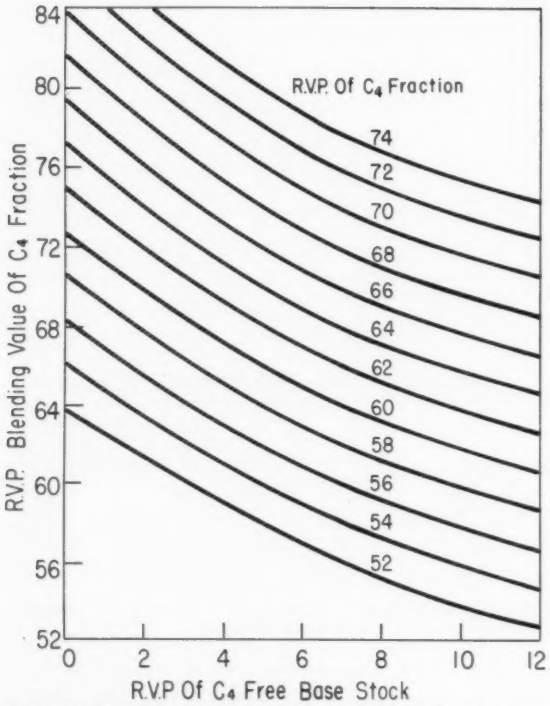


FIGURE 30—Blending values for Rvp of C, fractions can be obtained by knowing their actual Rvp.

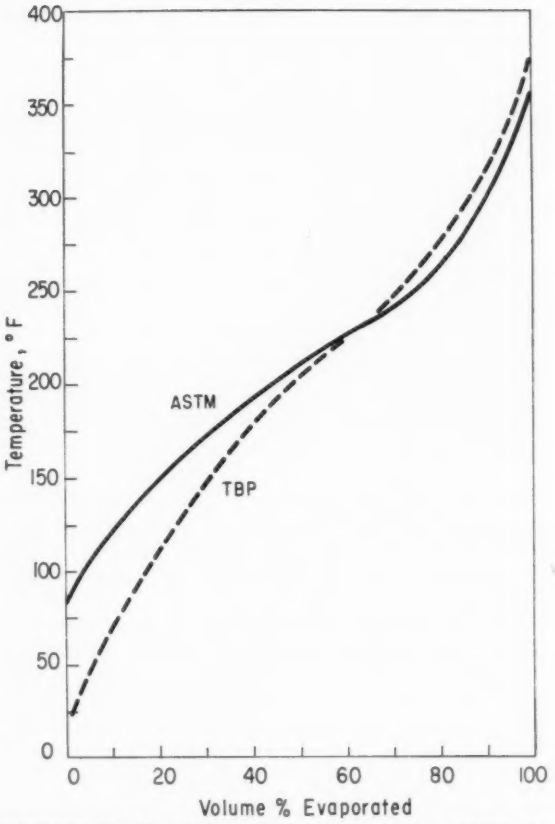


FIGURE 31—Correlations exist for converting ASTM distillation curves to TBP curves.

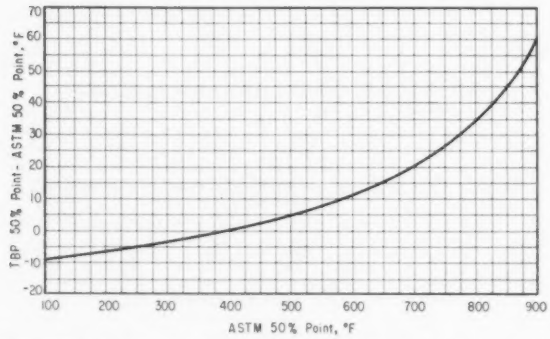


FIGURE 32—Use this chart to get 50% points for a TBP curve.

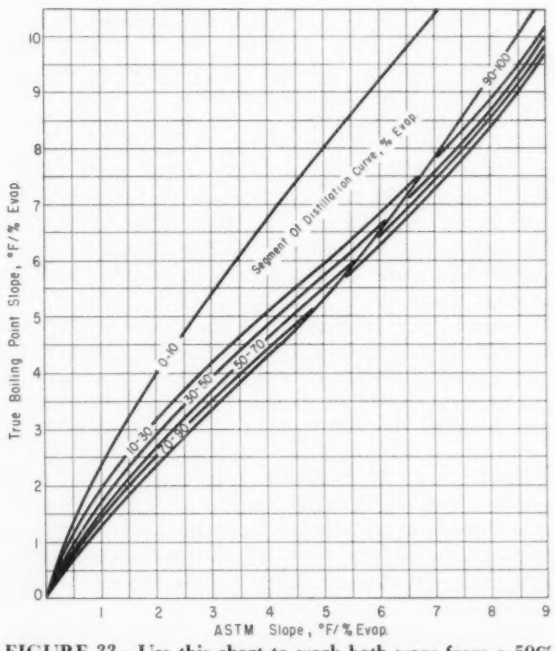


FIGURE 33—Use this chart to work both ways from a 50% reference point on a TBP curve.

vapor pressure and the front portion of the distillation curve. A definite relation between the Rvp and the 5 and 20 percent evaporated temperatures of a large number of gasolines has been observed.[69, 98] However, practical application of this relation is probably limited since the study was made a number of years ago. More recently, Haskell and Beavon[41] developed a method for determining the 10 percent point of a blend by relating Rvp and this distillation temperature. The correlation between Rvp and 10 percent point is shown in Figure 35. This relation was based on over 1200 gasolines, with 88 percent of the samples varying less than 1 psia from the average curve. The method itself employs blending or "effective" Rvp values for components, which are averaged volumetrically and converted to the 10 percent temperature by use of Figure 35. Effective Rvp's of all but the lightest stocks are taken

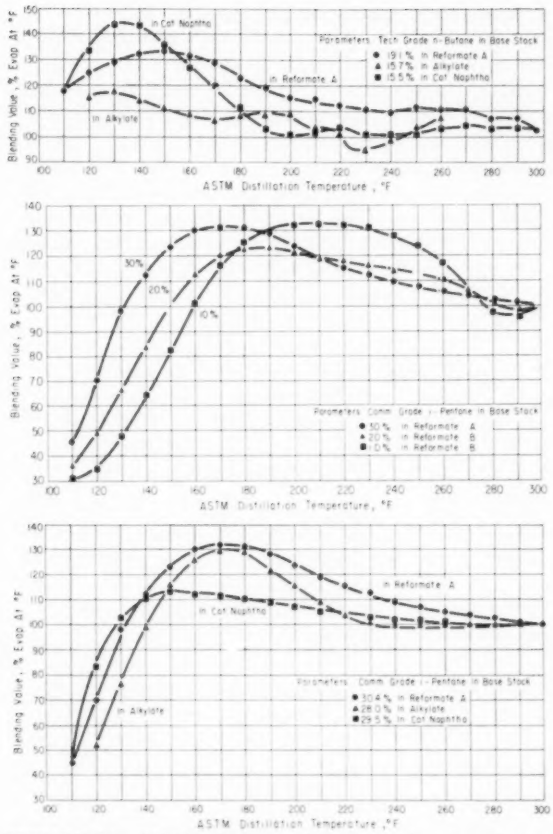

Blending Value, % Evap At °F
ASTM Distillation Temperature, °F
Parameters: Test Grade n-Butane in Base Stock
● 19.1% in Reformate A
▲ 15.7% in Alkylate
■ 15.5% in Cat Naphtha
in Reformate A
in Alkylate
in Cat Naphtha
Parameters: Comm. Grade i-Pentane in Base Stock
● 30% in Reformate A
▲ 20% in Reformate B
■ 10% in Reformate B
30%
20%
10%
● 30.4% in Reformate A
▲ 26.0% in Alkylate
■ 29.5% in Cat Naphtha

FIGURE 34—ASTM distillation blending values for n-butane and isopentane were determined in the base stocks reported in Table 14.

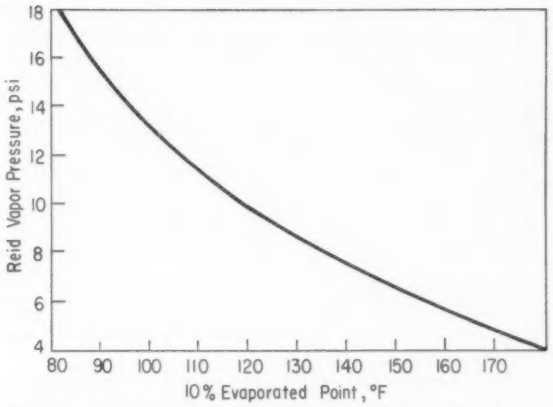


FIGURE 35—One method of blending relates the Rvp to the 10% evaporated point.

from this curve. The effective Rvp is taken for pentane fractions as equal to the actual Rvp and for butane fractions as equal to the blending values shown in Figure 30. A special correlation was developed for natural gasolines. The over-all accuracy of this method for predicting 10 percent point was reportedly better than 2° F.

BLENDING FOR ANTIKNOCK QUALITY

Laboratory Octane Number. Calculation of the effects of pressurizing agents on gasoline octane number is a necessary step in optimizing refinery blending. Research octane long has been used as a prime measure of antiknock quality. With the increasing importance of high-speed and part-throttle knock in modern cars, however, specifications for both Research and Motor octane numbers are becoming more common in the refinery. Light paraffinic blending agents are important in meeting these specifications because they are high in both Research and Motor quality.

A number of techniques have been devised to improve the reliability of calculating laboratory octane numbers of gasoline blends.[10, 23, 30, 37, 49, 71] While it is beyond the scope of this discussion to detail these methods, they generally represent one of the following approaches:

1. Blending values derived for various stocks based on their behavior in a common base stock.

2. Corrections applied to the octane number. These corrections depend on some combination of the following factors:

- proportion of components
- octane level of components
- type of stocks
- hydrocarbon type of components
- sensitivity of components.

Many of the techniques which approach universal application are basically non-linear.[44, 83, 91] These methods use actual octane ratings of the stocks and apply corrections for some of the factors mentioned above. Research and Motor ratings of light hydrocarbons are shown in Table 15.

Octane blending values find wide use for calculations when blending light agents. Research and Motor blending numbers developed for *n*-butane and isopentane, respectively, in three typical base stocks are presented in Table 16.[35] Because of variations with base stocks and concentrations, it is impossible to cite blending values for all refinery situations. Examples of the wide range in octane blending numbers commonly encountered are illustrated for three light compounds (at 3.0 ml TEL per gallon) in Table 17.

Heath and Hicks[45] have cited blending octane numbers for many light hydrocarbons in various blends having Reid vapor pressures less than 15 psi. Nelson has presented a formula based on correction factors which weight the octane rating of a component according to its blending effects.[71]

Road Octane Number. The ultimate effect on road antiknock performance of blending light hydrocarbon streams can be calculated by use of road correlation equations. Equations such as the following are well known and facilitate prediction of relative road performance among fuels:[84]

$$\text{Road ON} = a + b\,(\text{RON}) + c\,(\text{MON}) + d\,(\%\ \text{Olefins}) + e\,(\text{TEL})$$

COMPUTER APPLICATIONS

The solution of refinery blending problems by linear programming requires that all blending operations be described in linear form. Yet, octane number does not blend linearly and, unfortunately, the most accurate techniques to predict the vapor pressure and octane quality of blends are based on non-linear correlations. Thus, they are only indirectly applicable to computer

TABLE 15—Laboratory Octane Ratings of Volatile Hydrocarbons[a] (C_3 through C_5)

	RESEARCH METHOD					MOTOR METHOD				
ml TEL/Gal. Added	0.0	1.0	3.0	20 Percent Blend[b] 0.0	Blending Octane No.[c] 0.0	0.0	1.0	3.0	20 Percent Blend[b] 0.0	Blending Octane No.[c] 0.0
Saturates										
Propane	111.4	.....	.....	.....	.....	97.1	.....	.....	.....	.....
	112.5									
n-Butane	94.0	101.8[g]	104.4[g]	70.6	113	89.1	104.4[g]	104.4[g]	70.7	114
	93.6					90.1				
iso-Butane (2-Methylpropane)	100.3[g]	.....	.....	72.4	122	97.6	.....	.....	72.1	120
	102.1									
n-Pentane	61.7	75.5	84.8	60.3	62	63.2	78.5	84.8	61.3	66
		74.9	84.6			61.9	77.1	83.6		
			88.7							
iso-Pentane (2-Methylbutane)	92.3	104.4[g]	108.6[g]	67.9	100	90.3	>100	.....	68.7	104
neo-Pentane (2, 2-Dimethylpropane)	85.5	97.4	101.3[g]	68.0	100	80.2	93.0	99.9	66.0	90
					116[e]					
Unsaturates										
Propylene (Propene)	101.3[g]	.....	.....	.....	102[e]	84.9	.....	.....	.....	.....
	102.5									
Butylene (1-Butene)	97.5	.....	.....	76.7	144	79.9	.....	.....	73.2	126
					112[e]	81.7				
Butylene (2-Butene, cis-trans)	99.6[h]	.....	.....	78.7	153	86.5[h]	.....	.....	73.8	129
	100.0					83.5				
iso-Butylene (2-Methylpropene)	103.1[h]	.....	.....	81.9	170	88.1[h]	.....	.....	75.8	139
						87[d]				
Amylene (1-Pentene)	90.9	.....	98.6	71.7	119	77.1	81.3	82.9	69.8	109
	92.0[d]				99[e]					
(2-Pentene, cis)	.....	.....	.....	78.7	154	.....	.....	.....	75.3	138
(2-Pentene, trans)	.....	.....	.....	77.9	150	.....	.....	.....	74.7	134
(2-Pentene, cis-trans)	98.0[d]	.....	.....	.....	125[e]	80.0[d]	.....	.....	.....	107[e]
(2-Methyl-1-butene)	102.5[g]	.....	103.5[g]	77.1	146	81.9	.....	84.2	74.5	132
(3-Methyl-1-butene)	f	f	f	73.8	129	f	f	f	73.0	125
(2-Methyl-2-butene)	97.3	99.0	99.2	83.1	176	84.7	85.5	85.8	76.1	140
	98.0[d]				157[e]					122[e]

[a] Unless otherwise noted, all ratings were developed under API Research Project 45.
[b] Standard ASTM rating of 20 percent hydrocarbon + 80 percent 60:40 mixture of isooctane-n-heptane.
[c] For API data, calculated blending number of 20 percent hydrocarbon from above rating[b]. Number is extrapolated from rating at 20 percent concentration to a hypothetical 100 percent concentration.
[d] Compiled by Doss from various sources, "Physical Constants of the Principal Hydrocarbons," The Texas Company (1943).
[e] Compiled by Doss[d]. Concentration of 1 g-mol hydrocarbon/liter of solution in reference fuel of 55 octane number. Blending numbers were calculated from aniline equivalents.
[f] Too volatile to run as a liquid in the CFR engine.
[g] Based on expression: Octane No. (above 100) = $100 + \frac{PN-100}{3}$.
[h] Data source unknown.

optimization studies. Methods of applying volatility and octane restrictions, including non-linear correlations, to linear programming problems have been described.[26,94]

The calculations which can be applied directly in linear programming are those in which a blend quality is computed in some way as a weighted average. A general approach involves the use of blending numbers. Since blending values apply only over a narrow range in composition they must be based on blends representing formulations close to the expected solution. If the actual solution is much different than originally assumed, the blending values must be adjusted and the problem rerun. After a number of iterations, the blending values become constant as the assumed and calculated compositions converge.

A new method of calculating octane numbers of blends, based on a revised scaling system and directly usable in linear programming has been described.[43]

VOLUME CHANGES IN BLENDING

Volume changes occur in blending because petroleum mixtures do not form ideal solutions. Interactions are known to take place between those molecules in a blend which differ in character. Since most solutions of petroleum hydrocarbons contain a large variety of molecules, it is expected that there will always be some change in total volume associated with blending. Such a change can be either a gain or loss of volume but is more often the latter.

For heavy or full-boiling stocks, these effects are practically negligible, amounting to 0.1 or 0.2 volume—per cent total change. But, significant losses can take place when low-boiling hydrocarbons are blended with heavier stocks. One common instance of this is the charging of natural gasolines and various condensates into the crude-oil stream in a pipeline. Losses in volume when light liquids are transported in pipelines along with crude have been investigated.[17] The blending of volatile hydrocarbons to produce gasoline of specified vapor pressure also results in a final pool volume that is less than the total volumes of the components. Ap-

TABLE 16—Octane Blending Values of Normal Butane and Isopentane

Volume % in Base Stock	Research ON @ ml TEL			Motor ON @ ml TEL		
	0.0	1.5	3.0	0.0	1.5	3.0
n-Butane (Technical Grade)						
15.7% in Alkylate	95.5	98.6	101.9	94.8	99.2	104.0
15.5% in Cat Naphtha	92.1	100.3	102.2	86.8	95.3	98.4
19.1% in Reformate	93.7	98.3	100.7	89.2	95.3	98.7
Average	93.8	99.1	101.6	90.3	96.6	100.4
Isopentane (Commercial Grade)						
28.0% in Alkylate	93.7	101.6	103.2	87.4	100.9	103.1
29.5% in Cat Naphtha	92.3	100.2	101.5	86.4	93.6	96.7
30.4% in Reformate	91.8	98.7	101.3	86.6	94.3	101.9
Average	92.6	100.2	102.0	86.8	96.3	99.3

TABLE 17—Octane Blending Values for Light Compounds (at 3 ml TEL/gallon)

	RON	Blend RON	MON	Blend MON
n-Butane	104.4	100—110	104.4	91—112
Isobutane	....	104—118	....	100—120
Isopentane (commercial)	104.1	102—106	104.6	97—107

parent losses in most cases are small percentage-wise (usually less than one volume percent of total blend). Yet, they are of economic importance when large volumes of fuel are involved.

No simple relation has been found between volume changes and chemical or physical properties. Basically, shrinkage is a function of the molecular weights of the components involved and their concentrations in a blend. This has been shown by Reeves,[80] who developed an empirical expression for calculating volume losses in binary blends as follows:

$$\log C = 0.6107 \log (100 - P) + B \log M_1 + 0.537 \log (M_2 - M_1) + 4.418$$

where C = volume percent contraction
P = weight percent of heavy fraction in blend
M_1 = molecular weight of light component
M_2 = molecular weight of heavy component
B = constant

This equation was derived from a relatively small amount of data available in the literature. The constant B depends on the molecular weight of the lighter component. Values of B for various stocks are as follows:

Hydrocarbon	Molecular Weight	B
Ethane	30	—3.67
Propane	44	—3.81
Butane	58	—3.83
Gasoline and heavier	100	—3.50

For components with molecular weights of 100 or more, B remains constant at —3.50. The equation holds for blending under atmospheric pressure at temperatures of 60-70° F. Differences between calculated and observed losses for various blending schemes were reported to be about 20 per cent of total volume change.

Volume changes for binary blends can also be established by use of volumetric blending values, which attribute all losses to the light fraction. Blending values of various light compounds are shown in Figure 36[79] as a function of the molecular weight of the heavy component. These values apply when blending 15 per cent or less of the light agent. For example, when adding butane to gasoline (110 molecular wt.) at 100° F, the apparent volume of butane is 97.8 per cent of the quantity actually blended. For 10 per cent butane addition, this amounts to 0.22 per cent contraction or a loss of about one barrel per 500 barrels of total fuel.

Volume shrinkage is influenced decidedly by temperature and to a lesser degree by pressure. Temperature effects illustrated in Figure 36 show losses increase significantly as temperature rises. The blending volumes for butane at 70, 100 and 130° F are .990, .978 and .969, respectively. Losses have been shown to vary only slightly for pressures below 10 atmospheres.

TABLE 18—Volume Changes in Blending

Weight Fraction			Volume Changes at Given Temp., %				
n-Butane	Benzene	Cyclohexane	60.0 °F	80.0 °F	100.0 °F	120.0 °F	140.0 °F
0.090	0.910	0.	—0.18	—0.23	—0.30	—0.39	—0.50
0.180	0.820	0.	—0.29	—0.45	—0.60	—0.74	—0.86
0.391	0.609	0.	—0.44	—0.58	—0.78	—1.04	—1.36
0.648	0.352	0.	—0.38	—0.48	—0.65	—0.87	—1.14
0.812	0.188	0.	—0.22	—0.29	—0.40	—0.54	—0.71
0.096	0.	0.904	—0.21	—0.27	—0.35	—0.44	—0.53
0.196	0.	0.804	—0.40	—0.50	—0.62	—0.77	—0.94
0.425	0.	0.575	—0.61	—0.74	—0.92	—1.14	—1.40
0.673	0.	0.327	—0.56	—0.68	—0.85	—1.04	—1.29
0.262	0.396	0.342	—0.10	—0.25	—0.42	—0.61	—0.81
0.413	0.194	0.393	—0.39	—0.57			

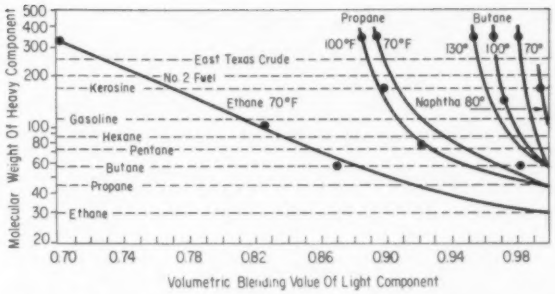


FIGURE 36—Usually there is a volumetric shrinkage when stocks are mixed together.

Blending effects when mixing *n*-butane with benzene and/or cyclohexane also have been cited.[19] Volume changes for butane concentrations from 10 to 80 weight—per cent (specifically, 12, 25, 50, 75 and 88 volume—per cent) in each of the aromatic stocks are listed in Table 18. Data covering two ternary blends are included.

Although based on a relatively small amount of data, the above references generally cite apparent losses of about 0.1 to 0.5 volume—per cent when blending butanes or pentanes in concentrations below 25 per cent in gasoline. The exact shrinkage depends largely on temperature and also on the molecular weight and structure of the heavier stocks involved.

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[106] Winn, "Physical Properties by Nomogram," *Petroleum Refiner*, Vol. 36, No. 2, Feb. 1957, pp. 157-9.

About the Authors

Unzelman

George H. Unzelman has recently been promoted to chief refinery technologist for Ethyl's Western Region and now is located in Los Angeles. When this article was prepared, Mr. Unzelman was technical assistant to Advertising and Sales Promotion for Ethyl Corporation in New York where he was involved in various technical writing assignments and films dealing with refinery subject matter. Mr. Unzelman joined Ethyl Corporation in 1955 at Detroit and was transferred to Tulsa in 1956 as a sales refinery technologist. Prior to joining Ethyl, he was associated for eight years with Continental Oil Company's Manufacturing Department at both the Ponca City and Billings refineries.

Forster

Eugene J. Forster is a project engineer in the Motor Fuel Section of Ethyl's Refinery Technology Division at the Detroit Research Laboratories. He works mainly in the field of fuel behavior research doing special customer studies along with contact and consultation work. In 1958, Mr. Forster was also on special assignment with Sales at Ethyl's Southern Region Office in Tulsa, Okla. After joining Ethyl Corporation in 1955, Mr. Forster spent a short period in the army as an officer in the Chemical Corps at Fort McClellan, Ala. He is a graduate of the University of Detroit, having received a B.Ch.E. degree in 1955.

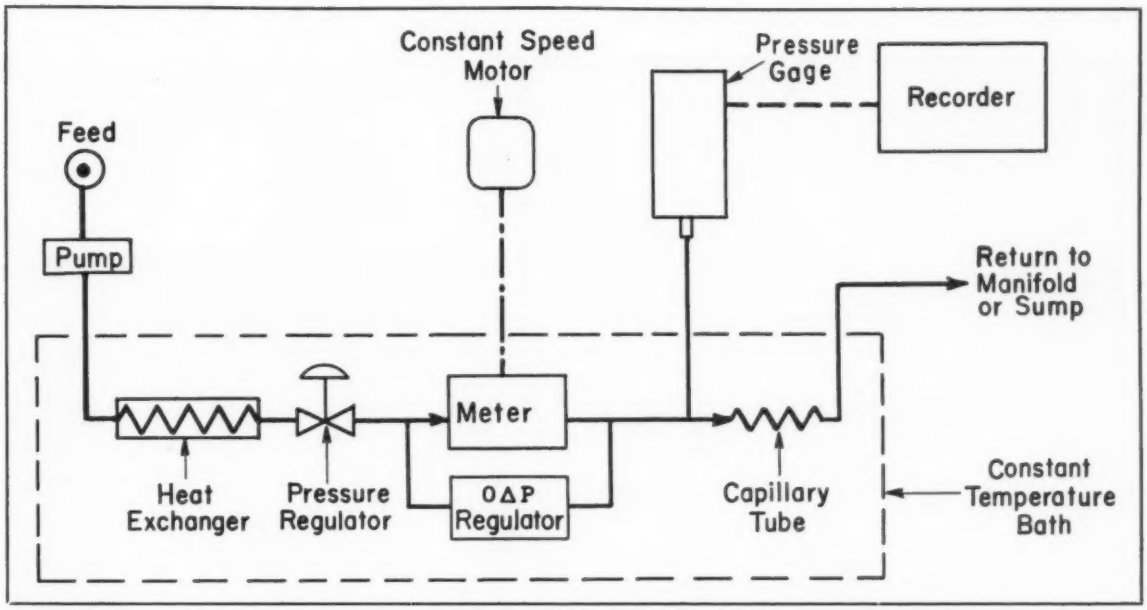

FIGURE 1—The pressure drop across the capillary is proportional to the absolute viscosity of the sample.

Process Viscosimeter Speeds Operation

New instruments which give onstream measurement of viscosity shorten the time required to take corrective steps in processing. Here is the principle for one such instrument and where it has been used to advantage

S. Frederick Kapff
Standard Oil Company (Indiana), Whiting

VISCOSITY MEASUREMENTS can be made automatically now with sufficient accuracy to assist an operator in producing specification products. A continuously indicating viscosimeter gives the operator current information on the state of the process so that he can make any necessary adjustments. Thus the instrument gives more efficient operation throughout the many processing steps, from crude oil to finished lubricants.

Laboratory measurement of viscosity, while accurate and fairly rapid, is not suitable for control of processing units. The time lag inherent in sampling, transporting the sample to the laboratory, testing and reporting the results to the operator is too great for close control of units. The operator needs continuous information to eliminate off-specification production.

An onstream viscosimeter gives a tightening of operation and an increase in efficiency. In distillation units, the product streams are maintained on specification by viscosity monitoring instruments. In dewaxing units, the segregation of products can be accomplished most accurately with the aid of viscosity monitoring instruments. In final blending, elimination of off-specification blends and more efficient utilization of blending equipment are made possible.

The first continuous viscosimeters in the Standard Oil Company (Indiana) system were installed on an experimental basis at the Whiting refinery on a lube oil blending system. None of the commercial instruments then available were fast enough or accurate enough. Therefore, special instruments were developed. Today, there are about 20 viscosimeters in use in various Standard Oil refineries, monitoring viscous materials from light lubricating oils to heavy resids. The operating characteristics of these instruments are given in Table 1.

HOW THE VISCOSIMETER WORKS

The process instrument discussed here is a capillary type in which the oil sample is supplied to the capillary at a constant temperature and at a constant volumetric rate. Under these conditions, the pressure drop across the capillary is proportional to the absolute viscosity of the oil sample. The entire instrument has been made explosion-proof for location at a process unit.

A schematic flow diagram of the continuous flow instrument is shown in Figure 1. Oil is supplied to the instrument from the process line either by a pump or

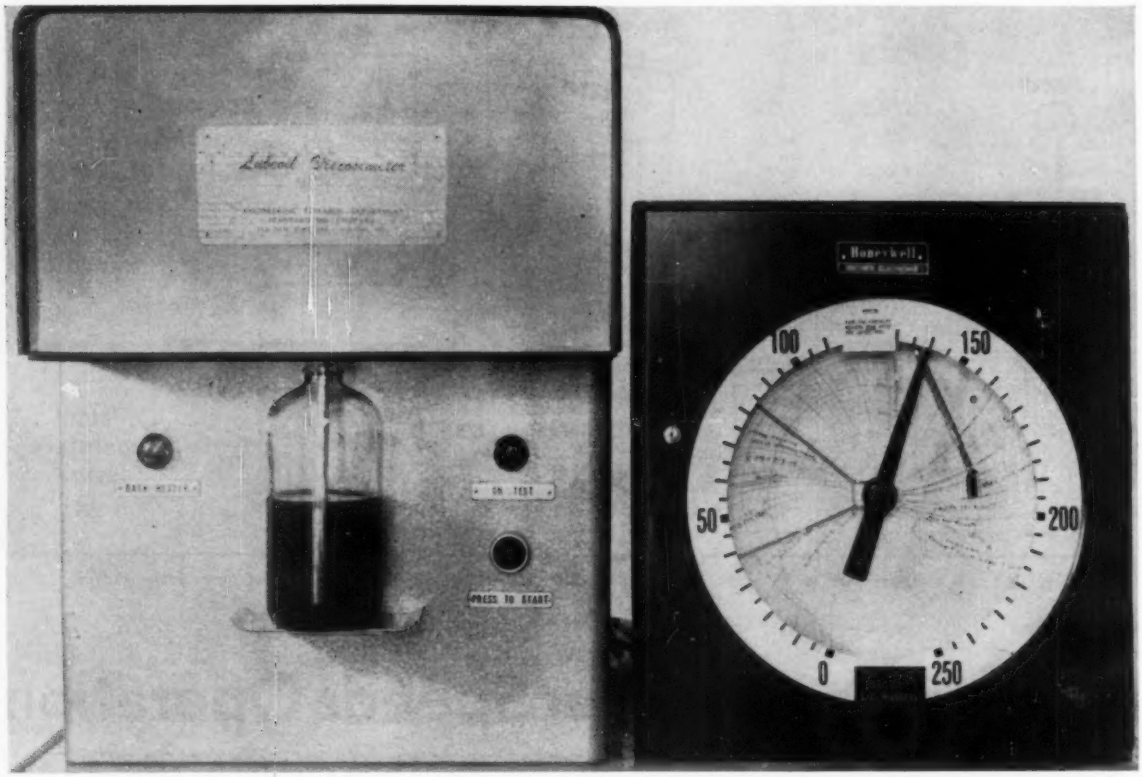

FIGURE 2—The batch instrument takes its feed from a sample bottle.

by process pressure. After being brought to constant temperature by a heat exchanger, it passes through a pressure regulator which provides constant feed pressure to a zero pressure differential metering device which provides a constant oil feed to the capillary. Pressures are read by a gage-recorder system.

Maintenance requirements on these instruments are small. Instruments maintain their calibration for long periods. When calibration does drift, a check of metering rate and pressure gage output is usually sufficient to spot the trouble.

A viscosimeter model operating batchwise has also been used. The batch instrument shown in Figure 2 takes its feed from a sample bottle.

SOME EXAMPLES OF ITS USEFULNESS

Lube Oil Continuous Blending. The first process viscosimeters for Standard Oil were installed to increase the efficiency of lube oil blending operations. While essentially running continuously, the blending facilities must produce so many products that only short runs of any particular composition are required. These frequent changes in blends caused much idle time of the equipment while operators waited for laboratory reports of product viscosity. With individual products blended from as many as five components, the blends were previously set by adjusting all valves and pumps to settings estimated to be correct. A short run was then made and a sample drawn for laboratory viscosity measurements. If the blend was on specs, the run was continued. During the period of waiting for laboratory analyses, the blending facilities were not usable. This down-time was intolerable with

TABLE 1—Viscosimeters in Use at Standard Oil (Indiana) Refineries

Instrument No.	Type of Service	Visc. Range	Temp. °F
1	Lubricant Blending	0–100 SUS	210
2	Lubricant Blending	0–100 SUS	210
3	Lubricant Blending	50–600 SUS*	100
4	Lubricant Blending	0–100 SUS	210
5	Propane Dewaxed Lubes	35–105 SUS	210
6	Vacuum Tower Bottoms	0–200 SFS	122
7	Lube Oil Distillate	50–100 SUS	100
8	Lube Oil Distillate (SAE10)	85–100 SUS	130
9	Lube Oil Distillate (SAE20)	65–75 SUS	180
10	Lube Oil Bottoms	250–500 SUS	210
11	Deasphalted Oil (SAE40-50)	70–100 SUS	210
12	Deasphalted Oil (SAE70)	130–155 SUS	210
13	MEK Dewaxed Lubes	30–220 SUS	210
14	MEK Dewaxed Lubes	35–105 SUS	210
15	Vac. Tower Bottoms	100–250 SFS	122
16	Vac. Tower Bottoms	100–250 SFS	122
17 (N)	Vac. Tower Bottoms	500–1600 SFS	210
18 (B)	Lubricant Blending	35–105 SUS	210
19 (B)	Lubricant Blending	35–185 SUS	210
20 (B)	Lubricant Blending	0–2500 SUS*	100

* Dual Range.
N = Commercial Instrument.
B = Batch Type.

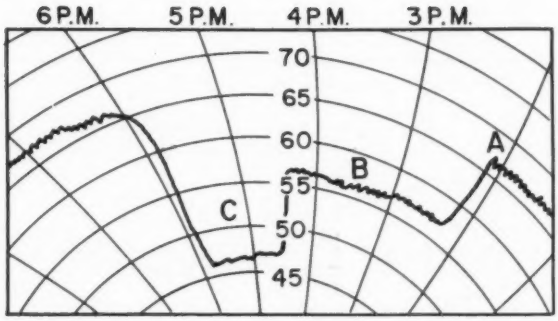

FIGURE 3—The instrument shows rapid response to large changes in viscosity of the blend from 67 SSU at A, to 56.6 SSU at B, to 47 SSU at C.

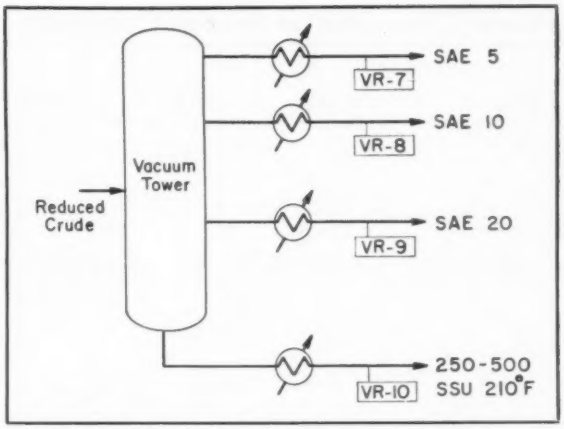

FIGURE 4—Four viscosimeters were installed on streams from the vacuum distillation unit.

the tight scheduling that required maximum production from all facilities.

Continuous viscosity instruments on the blending lines have reduced the dependence on lab analyses by providing the operators with continuous measurements. They are installed to take their feed from the blending lines just before the blend passes to tankage. All valves and pumps are set, as previously, but now corrections and adjustments in settings can be made on the spot. The blends can be run to shipping tanks on the basis of the viscosity readings on the instruments. The waiting period for laboratory analyses has been eliminated, and facilities can be run at maximum efficiency.

A typical recorder chart from a blending viscosimeter is shown in Figure 3. This shows several large changes in blend viscosity. The rapid response of the instrument, and the absence of overshoot are obvious.

Lube Oil Batch Blending. Many lubricant compositions are manufactured in such small volumes that batch blending in large kettles is employed. The various components of the blend are pumped into a kettle in the required amounts. After mixing, a viscosity check must be made, and during this period the blend is retained in the kettle. For maximum efficiency, this waiting period must be made as short as possible. Conventional testing at a remote laboratory was out of the question. Even laboratory tests on the spot took too long.

Because of the large number of individual blending kettles, the piping system expense for any reasonable number of continuous viscosimeters would have been prohibitive. Batch testing seemed to be the answer. Two batch type viscosimeters were installed close to the blending system. With these, viscosity readings can be obtained in about 90 seconds. Thruput of the blending system has been noticeably increased because of the decreased waiting time for analyses.

Lube Stock Distillation. A vacuum tower distilling lubricants is operated so that the various distillates meet viscosity specifications. Here again the time required to take samples, transport them to the laboratory for measurements, and report the results back to the unit precluded accurate unit control. As a consequence, the products were run to holding tanks where they remained until laboratory results on product viscosity could be obtained. Numerous tanks had to be provided solely for retaining the products until testing was completed.

To aid in vacuum tower operation, four continuous viscosimeters were installed on streams from the tower shown schematically in Figure 4. One serves to monitor the light distillate stream having a viscosity less than the SAE10 grade. Two others monitor SAE10 and SAE20 streams while the fourth monitors the tower bottoms. From the readings of these instruments any deviations from specification targets are immediately apparent. Adjustments can be made in the tower controls to bring all products back within specifications before any sizable viscosity variations occur. Such variations are now small enough that products can be run directly to further processing.

Considerable savings in capital costs have been realized by the elimination of the intermediate holding tanks which would have been required without installation of the viscosimeters.

Deasphalting. The bottoms stream from the tower of Figure 4, monitored by the viscosimeter shown, is run directly to propane deasphalting for production of heavy lubricants and cylinder oils. The deasphalting operation is monitored by viscosimeters located on the depropanized extract streams. When scheduling changes require changes in product, these instruments serve to indicate the product changes and permit accurate switching of tanks. In this way product degradation is reduced.

Lube Oil Dewaxing. The dewaxing of lubricants by propane or MEK is a process characterized by being continuous, but operating with many changes in feed stocks. Depending upon production schedules, the feed

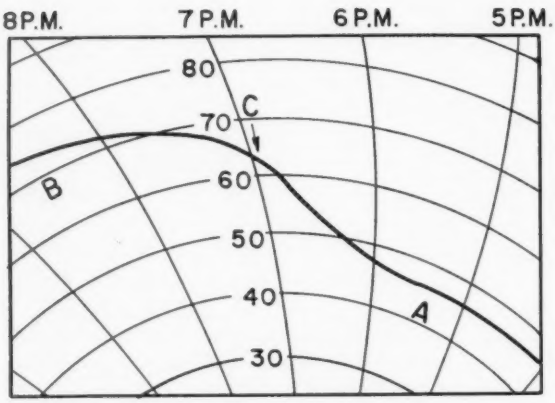

FIGURE 5—This typical chart from the viscosimeter at the dewaxing plant shows the change in viscosity of product from 47 SSU at A to 74 SSU at B. Product receivers were switched at point C.

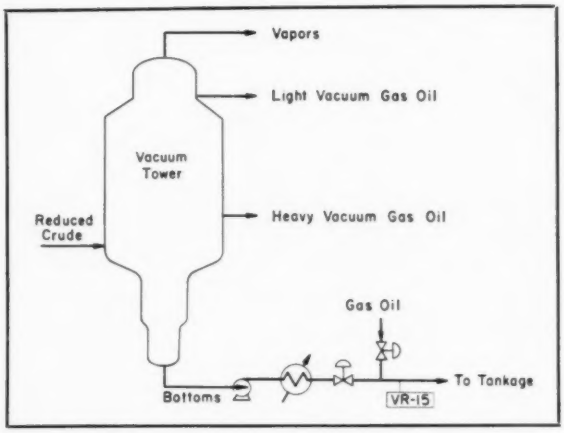

FIGURE 6—A continuous viscosimeter on the vacuum tower bottoms can monitor the amount of gas oil needed to maintain the desired viscosity of the material going to storage.

may change abruptly from one viscosity grade to another. For minimum product degradation, it is desirable to recognize the change in the product stream immediately upon occurrence. This is difficult to schedule on a time basis because about three hours are required for a given feed change to pass through the plant.

When attempts to use the color of the product to detect produce changes were unsuccessful, continuous viscosimeters were installed on product lines. These instruments were immediately successful in detecting product changes so that product switching can now be accomplished easily. A chart showing a typical change in product viscosity is shown in Figure 5. It can be seen that approximately two hours are required for completion of the product change. Product tanks were switched at point C with a minimum of product degradation.

Crude Oil Resids. Vacuum distillation of crudes results in heavy residuals or asphalts as undistilled bottoms. These heavy bottoms are frequently diluted with gas oil to produce residual fuels. As the bottoms stream comes from the vacuum tower, gas oil is added immediately as shown in Figure 6 in ratios from 1:1 to 2:1 gas oil to resid. With a continuous viscosimeter on such a line the blend sent to tankage can be maintained in the desired viscosity range at all times. This eliminates the need for further blending in tankage. It also serves to conserve on gas oil by prevention of over-dilution.

Under manual control considerable variation in stream viscosity is still observed. For better uniformity, the installation of automatic control is being considered to regulate the gas oil injection.

Asphalt Production. The bottoms stream from vacuum distillation of crude in Figure 6 is frequently run without dilution to asphalt processing. Uniformity of product has been aided by installation of a continuous viscosimeter. The viscosity of this stream was found to be above the present range of the refinery viscosimeter. A commercial viscosimeter for asphalt service was immediately available and was installed. The extension of the range of the refinery instrument to include heavy asphalt is being studied.

Grease manufacture is a batch operation requiring rapid viscosity measurements. Many individual components must be mixed in large kettles to produce a grease. Occasional batches of grease had to be reprocessed as off-specifications because production schedules demanded that the grease kettles be emptied before laboratory analyses could be completed. A specially constructed viscosimeter calibrated to read directly in penetration units was installed on a pumparound line from a grease kettle. Improvement in ability to hit specifications was observed immediately, particularly with the younger and less experienced operators.

OTHER APPLICATIONS POSSIBLE

The end of the line on the applications of process viscosimeters has not yet been reached. In certain operations in asphalt production, continuous viscosity monitoring or control seems attractive. Economic incentives for installing automatic control equipment on several of the older installations also are being investigated.

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About the Author

S. Frederick Kapff is head of the instrument development section of the Research and Development Department of Standard Oil Company (Indiana), Whiting, Ind. Holder of BS and PhD degrees in chemistry from University of Pittsburgh, Dr. Kapff is in charge of development of process monitoring instruments for refinery use. Before joining Standard in 1948, he was a fellowship assistant with Mellon Institute and a research chemist with Distillation Products, Inc.

Kapff

How to specify . . .

Staged-Opening Type Valve Trays

Because valve tray design procedures are not widely available, certain process information is required for optimum design

Francis W. Winn
Fritz W. Glitsch & Sons, Inc., Dallas

A DUTY TYPE specification is most often used when specifying valve trays because, as is true with practically all proprietary trays, the tray design procedure is not widely available. Therefore, it is important to include certain process conditions and mechanical limitations, if any, when specifying valve trays. The inclusion of these conditions will result in faster quotations and more important, a tray design which is optimum for the process.

The essential minimum information necessary is the internal vapor loads and liquid rates at top and bottom tray conditions. Vapor load is defined as the vapor rate in cu. ft./sec. (corrected for compressibility) times the square root of a density ratio.

$$V \text{ load} = \text{cfs vapor } \sqrt{D_V/(D_L - D_V)}$$

Although it is possible to design valve trays based on only the V load and liquid rate, a more thorough design frequently can be obtained with complete information shown on the Process Design Data Sheet (next page). It is not necessary to provide all the information requested unless the system has properties considerably different from those of conventional refinery and chemical separations. However, a better design, one which is more likely to give the desired separation, capacity, pressure drop and flexibility, will be obtained if complete information is given. The amount of time required to fill in the form is negligible when the importance of complete information is recognized.

The type of service involved, or variety of services, should always be given. Glycol dehydrators and amine absorbers are not designed by the same procedure as other service having identical densities and flow rates. If the system is frothy or has some other peculiar characteristic, the property should be described. As an example, a lacrimator might require a mechanical design which would permit disassembly of the tray by men working from the top or bottom of shell flanges. The design for such a tray could be quite different from one which is installed through manholes.

The allowable pressure drop, if specified, should not be made more restrictive than necessary. Certain valve trays can be designed for a very low pressure drop; however, an unnecessarily restrictive pressure drop limitation might reduce the number of trays to a point where the desired separation cannot be obtained without going to two more towers in series.

Turndown Ratio. Certain valve type trays of standard design can be operated over a range of vapor loads of approximately 10; i.e., the turndown ratio is 10. However, this does not necessarily mean that feed rates can be varied 10 to 1. If internal loads change from tray to tray appreciably, a part of the inherent turndownability is utilized for internal load variations. Turndown ratios up to 30/1 can be obtained with special designs. A turndown ratio of this magnitude usually involves strippers of a special nature but even ordinary strippers associated with absorber-stripper combination can have a 10/1 load variation. If the tray by tray loadings are available, this information should be given. If it is not available, a special design having the required turndown will be a necessity.

Downcomer Area. Frequently, an existing or given tower diameter is considerably larger than required. If a future increase in capacity is not contemplated, a less expensive design can be obtained by using larger downcomers than necessary or by increasing the cap spacing to reduce the number of units. Many customers wish to utilize excess potential capacity. For such cases, the standard close spacing of units is provided and the ratio of downcomer area to active area is maintained for design conditions. This provides both ade-

Process Design Data Sheet for Valve Trays

Item Number or Service				
Tower diameter, I.D.				
Tray spacing, inches				
Total trays in section				
Maximum ΔP, mm Hg				
Conditions at Tray Number				
Vapor to tray, °F				
Pressure				
Compressibility				
Density, lb/cu. ft.				
Rate, lb/hr.				
cu. ft./sec. (cfs)				
cfs $\sqrt{Dv/(D_L\text{-}Dv)}$				
Liquid from tray, °F				
Surface tension				
Viscosity, cp				
Density, lb/cu. ft.				
Rate, lb/hr.				
GPM hot liquid				
Tray material				
Valve material				

NOTES:
1. This form may be used for several sections of trays in one tower, for several towers, or for various loading cases. Use additional sheets if necessary.
2. Is maximum capacity at constant vapor-liquid ratio desired?_____
3. Minimum rate as percent of design rate:_____percent.
4. Allowable downcomer velocity (if specified):_____ft/sec.
5. Number of flow paths: single_____; double_____; three_____; four_____; Fabricator's choice_____.
6. Trays numbered: top to bottom_____; bottom to top_____.
7. Enclose tray and tower drawings for existing columns.
8. Manhole size, I.D._____inches.
9. Manways removable: top_____; bottom_____; top & bottom_____.
10. Corrosion allowance: c.s._____; other_____.
11. Adjustable weirs required: yes_____; no_____.
12. Packing material if required_____; not required_____.
13. Ultimate user_____.
14. Plant location_____.
15. Other_____.

quate downcomer area and the proper active area for future loads.

Weirs. Adjustable weirs are not required on valve trays unless the tray is to be used in vacuum service as well as other services. Very large diameter trays should have adjustable weirs to permit a correction for tray ring levelness.

Winn

About the Author

Francis W. Winn is director, research development, for Fritz W. Glitsch and Sons, Inc. A chemical engineering graduate of the University of Oklahoma, he was formerly technical director for Fractionation Research, Inc. He has been associated with a number of major oil companies and was assistant chief process engineer with Catalytic Construction Company.

Packing between truss joints and at the tray ring is not necessary unless operation at very low vapor rates is required. Packing material is not expensive but the installation of packing does require additional time. As an example, a 10 foot diameter tower with 60 trays requires about one mile of tape if fully packed.

Materials of Construction. Valve trays can be made of most metals including carbon steel, stainless steel, monel, nickel, ni.-cr. alloys, copper, aluminum and titanium. The valve proper is usually made of type 410 stainless steel when carbon steel decks are used. An exception is towers having HF present where either monel or carbon steel valve units must be used. The material of construction and the corrosion allowance should be specified.

Manholes. Obviously, manhole sizes are necessary to insure proper dimension of tray components. For tray replacement in existing towers, complete tower attachment drawings are essential. ##

KEEP UP WITH AUTOMATIC CONTROL

WITH PART 22, the author starts another series of articles to acquaint you with some of the basic concepts of automatic control. To get up-to-date on this important phase of the processing industry, you may want to go back and review these earlier parts:

PARTS	AUTOMATION TODAY	PETROLEUM REFINER
1— 4	Introduction to Process Control	April-July, 1956
5— 6	Using the Bode Diagram to Design	August-September, 1956
7—10	Application of Process Control	January-April, 1957
11—14	Using Computers and Test Methods	August-November, 1957
15—17	How to Use the Nyquist Diagram	October, 1959-January, 1960
18—21	Closed Loops and Root Locus Method	February-May, 1960

PART 22

Automation Today

Some control systems do not conform to the conditions of linear response. Since our past discussions dealt with linear systems, we will now explore some of the methods for handling nonlinear ones

Theodore J. Williams and Verlin A. Lauher
Monsanto Chemical Company, St. Louis

UNFORTUNATELY, only a certain fraction of the systems which must be considered in chemical process control can be characterized by the procedures of linear control system theory. In some cases the response of the system under consideration cannot be approximated by linear theory. In other cases, the deliberate inclusion of nonlinear elements can often result in a substantially improved response and controllability of the system under study. In this and the succeeding parts of this series we will consider both of these classes of nonlinear systems and describe how they may be treated.

COMPARE LINEAR AND NONLINEAR SYSTEMS

Linear systems are the starting point for study of basic automatic control system theory, and thus process control theory. Linear systems are those whose dependent variables exhibit the following characteristics:

- All dependent variables give a continuous response over the complete range of values involved.
- All coefficients of the differential equations of the system are either constants or functions of time only.
- Several forcing functions (driving forces) are applied at the same or different locations in the system at the same or a different time, the total response produced is the same as the sum of the responses to the individual functions considered separately. (This is the principle of super-position.)
- As is implied by its label, the magnitude of the response of a linear system is directly proportional to the magnitude of the input function. This permits the magnitude of the response to be normalized into the form of the magnitude ratio. This allows the use of such presentations as the Bode and Nyquist diagrams.

Nonlinear systems on the other hand, are those which do not follow one, several, or possibly all of the above rules. For example, the magnitude ratio of a nonlinear system is usually a function of its input magnitude. Thus, while the Bode diagram of a typical linear second-order system may follow only the solid curve of Figure 149 regardless of the input magnitude, the response of a nonlinear second-order system may include all the possible responses in Figure 149 as the input magnitude is varied.

As another example, the natural frequency of response of a typical nonlinear system may vary with its magnitude. On the other hand the response of a linear system, if oscillatory, is always at a constant frequency. As a result, the theory of nonlinear systems has been almost completely developed around discussions of their transient responses, in contrast to the great preponderance of frequency response considerations with linear systems.

Nonlinear systems usually give response to change that are dependent on both time and magnitude. Plotting these responses directly versus time are unhandy ways of presentation for long time periods. Thus the development of another method of presentation is necessary.

PHASE PLANE RESPONSE

Figure 150 gives the basis for one method of handling nonlinear systems. Let us consider a three dimensional space with the three space coordinates being, the system displacement, x, time, t, and the rate of change of displacement with the time, dx/dt. The time response of the system can then be plotted in the resulting three dimensional space. The projection of this response on the x-t, or time-domain plane, is the usual transient response of the system. The corresponding projection of this response onto the $x - \frac{dx}{dt}$, or phase plane is known

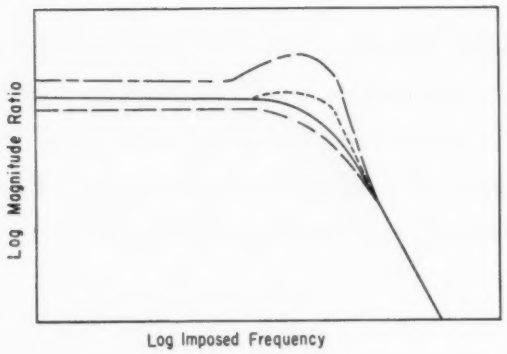

FIGURE 149—The Bode diagram of a typical linear second-order system is represented by the solid line. A nonlinear system may include all of the possible responses shown here as the input magnitude is varied.

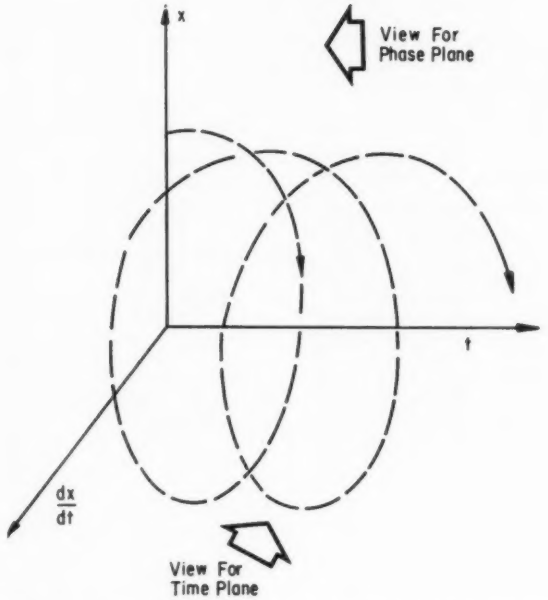

FIGURE 151—Here is the way one system vector appears for a phase plane response.

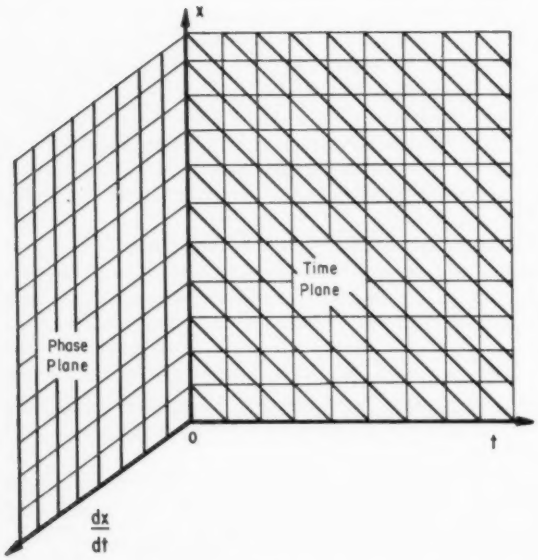

FIGURE 150—One method of showing a nonlinear system is represented by a three coordinate plot.

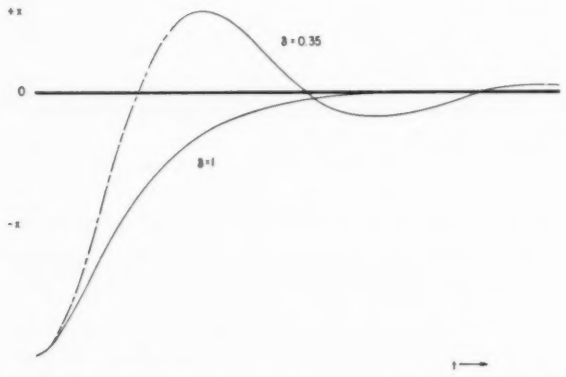

FIGURE 152—This transient response plot of a second-order linear system shows two values of damping factor.

as the phase response.[3] Figure 151 is a further diagram of the relation of the transient and phase responses of a system.

Figures 152-155 present several examples of phase planes for a second order linear system to further explain this plotting method. Several interesting points may be noted concerning them:

- The path of the system vector is clockwise in all cases. Thus the optimum damped system in Figure 153 is a rapidly decreasing spiral while the unstable system is a spiral increasing without limit. Notice that they are actually mirror images of each other.

- The effect of the magnitude of the input function is to vary the size but not the shape of the phase plane plot. Thus different magnitudes of input create a family of curves symmetrical about the origin (See Figures 154 and 155).

The second order linear equation used for Figures

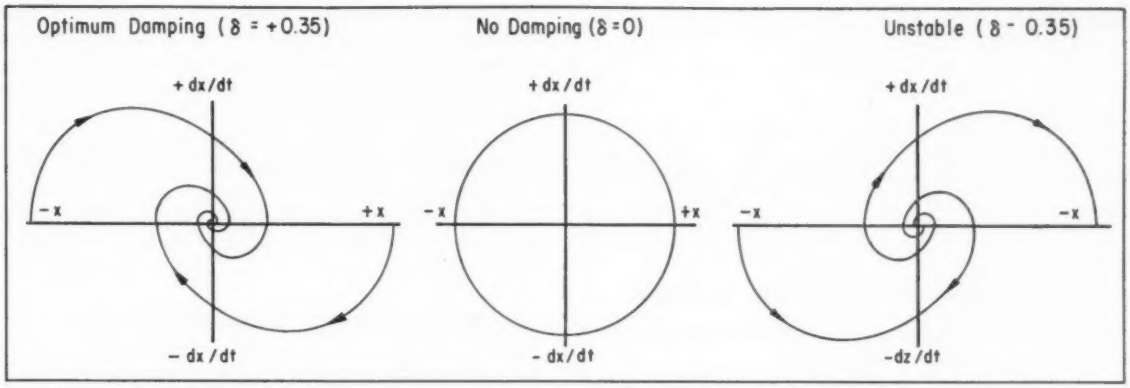

FIGURE 153—Here is the phase plane response of a second-order linear system for various values of damping.

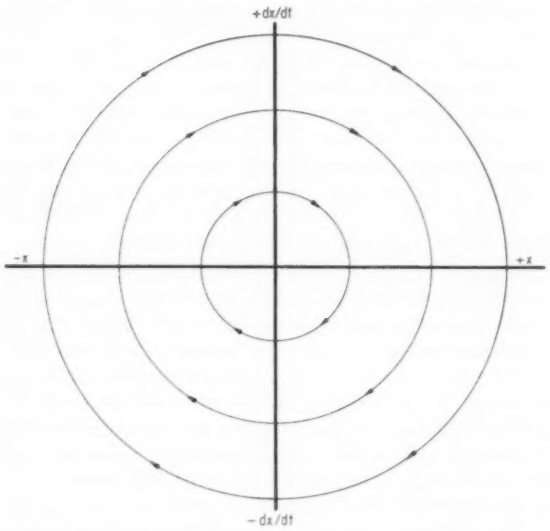

FIGURE 154—Phase plane response of second-order linear system with no damping showing effect of input signal magnitude.

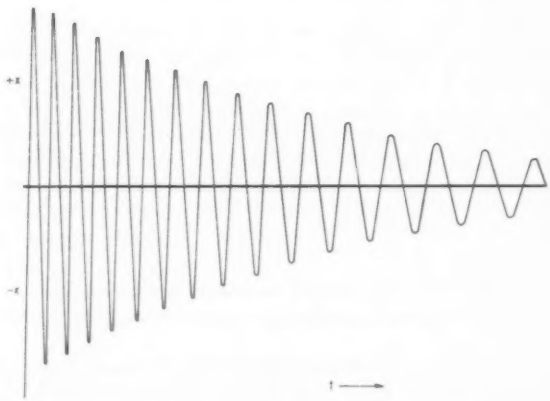

FIGURE 156—An example of how amplitude and frequency can change in a nonlinear system's response.

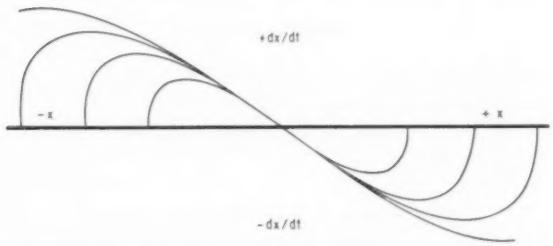

FIGURE 155—The effect of the magnitude of the input function is to vary the size but not the shape of the phase plane plot.

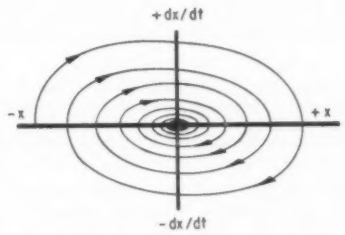

FIGURE 157—Note pronounced change in shape of spiral for nonlinear system on phase plane representation. This plot is for same system shown in Figure 156.

152-155 was the standard second-order differential equation form previously discussed in Part 2 (PETROLEUM REFINER, May 1956, p 209) and Part 5 (PETROLEUM REFINER, August 1956, p 163):

$$(T^2p^2 + \delta p + 1)\, x = 0, \text{ or}$$

$$(T^2 p^2 + 2\zeta Tp + 1)\, x = 0$$

By way of contrast the phase plane plot of the second order nonlinear system used to develop Figure 156 is given as Figure 157. In contrast to the symmetry of the preceding plots of Figure 153, note the pronounced change in shape of the spiral as it approaches the origin thus illustrating the effect of magnitude upon nonlinear system response. The equation for the system of Figures 156 and 157 is (3):

$$a\frac{d^2x}{dt^2} + b\frac{dx}{dt} + \alpha x + \beta x^3 = 0 \qquad (3)$$

where both $\alpha > 0$ and $\beta > 0$. The nonlinear term is of course, the βx^3.

WHY CONSIDER NONLINEAR SYSTEMS

Chemical process control systems can be nonlinear for one or both of two possible reasons:

- Systems whose action is so nonlinear that their approximations as the equivalent linear system would lead to drastic errors in computing the required responses.
- Systems made deliberately nonlinear to secure a specific or superior control response.

In the first category are all sets of equations describing kinetic systems where the order of any one of the reactions is of any higher degree than the first. It also includes such systems as those in fluid flow where a squared term is involved. Many other such systems can readily be brought to mind. In fact, a chemical process system is much more likely to be nonlinear than linear when the basic theory of its operation is considered. Our reference to them as linear systems is usually founded on one or more approximations or assumptions that linear theory can be applied without appreciable error.

Systems of the second type are becoming increasingly more important as research shows their definite superiority over standard linear systems for particular tasks. Among these are the use of such devices as nonlinear damping, adaptive control, bang-bang control and others which will be discussed more fully in succeeding parts of the series.

AN OUTLINE OF NONLINEAR THEORY

Much of the present theory of nonlinear control systems is based on and derived directly from the much older theory of analysis of nonlinear mechanics and nonlinear electronic circuits.[1] Although work has been conducted extensively in these fields throughout the last forty years, knowledge is still at a relatively low level compared to that for linear systems. This is due to the fact that general methods of solution, such as frequency response, are not possible. Thus specific solutions must be worked out for each different set of nonlinear equations if *analytical methods* are to be used. While much inspired work of this type has already been done the surface has barely been scratched to date. Therefore, recourse must be had to other possibilities.

Higgins, in his excellent review of the field,[1] has presented an extensive list of such possibilities. An abbreviated but similar list is presented here as Table 1. Of all those mentioned, the analog computer is especially recommended for use. It is capable of simulating nearly all types of functions normally considered in nonlinear control systems. In addition, its graphical method of presentation of results is especially suited for drawing the phase-plane plots usually used to represent the responses of nonlinear systems.

As with linear systems, solutions of sets of nonlinear equation are necessary to find out certain facts about the device under study. Several classes of required information are listed in Table 2.

TABLE 1—Some Available Methods of Solutions of the Equations of Nonlinear Control Systems

DIRECT ANALYTIC SOLUTION in closed form in terms of known functions, such as elliptic and hyperelliptic functions. These apply only to a relatively small special class of systems.
LINEARIZATION OF THE NONLINEAR TERMS in the equations. This may take several forms, such as:
METHOD OF SMALL PERTURBATIONS—it is assumed that the deviation from steady-state is small. Therefore, all nonlinear terms are treated as constants or considered to vary linearly with the independent variable.
SECTIONAL LINEARIZATIONS—The range of variation to be considered is broken up into regions and special linear forms of the nonlinear terms are written for each region and considered to apply throughout that region.
SERIES LINEARIZATIONS—The nonlinear terms are expanded in various series forms and the first terms used as an approximation over the region to be considered.
GRAPHICAL PROCEDURES as they relate to construction of phase plane (2 dimensional) and phase space (3 dimensional) plots of nonlinear system response. Some of the procedures are the isocline method, Lienard's method, arc-segment procedures, etc., ([1], [3]). However, these are almost impossibly difficult for anything more complex than a third order system so are not much used for anything other than instructional purposes.
ANALOG COMPUTER SOLUTIONS.
NUMERICAL METHODS of solution, particularly as carried out on digital computers.
(It will be seen that these methods are essentially the same as for linear systems except for the special investigations necessary with nonlinear phenomenon as brought out here.)

LITERATURE CITED

[1] Higgins, T. J., *Transactions of the ASME*, 79, 445-53 (1957)
[2] Ludeke, C. A., *Transactions of the ASME*, 79, 439-44 (1957)
[3] Rausch, L. L., *Theory of Oscillations of Nonlinear Systems*, University of Michigan, Ann Arbor, Michigan, 1957.

TO BE CONTINUED

TABLE 2—How To Study Nonlinear Systems

Determine the free or forced transient response of a system for certain values of the system parameters and for the system's initial conditions.
Determine the free or forced steady-state response of the system again for certain stated values of the system parameters and for certain specified initial conditions. If the response is oscillatory, determine how the amplitude, frequency, and nature of this cyclic response depends on the prescribed parameters and initial conditions. Resonance, autoexcitation and other such phenomena should be fully explored here.
Determine the stability criterion for both the steady state, and transient responses of the system.
Establish the degree of accuracy of various linearization procedures.

H-Oil Process Treats Wide Range of Oils

Recently completed pilot plant work indicates that the H-Oil process is adaptable to a wide range of residuums, heavy and light gas oils. See how it raises gravity, reduces sulfur and metals content

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Hydrocarbon Research, Inc., New York City

THE SCOPE of the H-Oil process has been broadened considerably over that described in a previous publication.[1] This article describes the process in greater detail and summarizes additional experimental work which demonstrates its use in a wide variety of petroleum refining applications.

Early hydrogenation schemes developed by the Germans utilized complex slurry-catalyst systems at very high pressures.[2] Since 1952, Hydrocarbon Research, Inc. has worked to develop a hydrogenation system which would be more satisfactory than that developed by the German workers. The following difficulties confront the development of a process which would be applicable to *any* petroleum stock:

1. Efficient contact is extremely difficult to obtain between hydrogen, oil and catalyst.

2. The deep hydrogenation of a heavy oil to lighter distillate products is accompanied by a very large release of heat. A successful process must cope with this heat in an economic design which will maintain preferred reaction temperatures.

3. In order to eliminate carbon formation, operating pressures must be extremely high (i.e., substantially above 5,000 psig). Although lower pressures are highly preferable from a cost standpoint, the formation of carbon reduces catalyst activity and leads to pressure drop difficulties.

4. Heavy oils likely to be charged in the hydrogenation process invariably contain organo-metallic compounds which deposit on the catalyst rapidly poisoning it.

5. In the conversion of heavy oils to lighter distillate materials, hydrogen consumption may be of the order of 1,000 cubic feet per barrel of oil charged. Until recently, there have been no available processes to produce such hydrogen cheaply, so that the cost of hydrogen has represented a major item in the over-all cost of hydrogenation.

The following summarizes how the H-Oil process has successfully solved these difficulties:

H-OIL PROCESS

In the H-Oil process, a mixture of oil and hydrogen is fed upshot into an ebullating bed of catalyst. In the ebullating bed, the catalyst is expanded somewhat in excess of its settled volume and is in a state of motion induced by the velocity of the oil and hydrogen. Expansion and motion of the catalyst allows a wide latitude with respect to the effect of reactor geometry and catalyst size on reactor pressure drop, and avoids the limitations of the analogous fixed-bed system by permitting fine solids to migrate through the bed and leave the reaction system. The motion of the catalyst together with the high velocity of oil in the system also results in intimate contact between oil, hydrogen, and catalyst, making the reaction system very efficient with respect to the amount of catalyst charged per unit of oil throughput. Catalyst attrition is insignificant, since the particles in motion in the ebullating bed are cushioned by an envelope of oil. Furthermore, unlike the German systems, the catalyst is retained within the volume of the reactor so that it is completely unnecessary to provide means for separation from the product oil and recharging to the system.

Figure 1 is an example of the expansion of an ebullating bed of a typical catalyst as a function of liquid and gas velocity. It should be noted that the top of an ebullating bed is sharply demarcated from the non-solid containing phase above it; unlike the analogous gas-solid

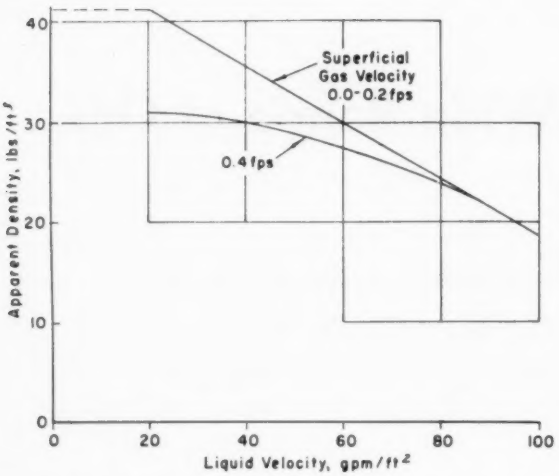


FIGURE 1—In this example of the expansion of an ebullating catalyst bed, notice that the top of an ebullating bed is sharply demarcated from the non-solid containing phase above it. Unlike the gas-solid fluidized bed, surging phenomena due to slugging can be avoided completely.

fluidized bed, surging phenomena due to slugging and "rat-holing" can be completely avoided.

Catalyst Replacement. An important collateral advantage of the ebullating bed is that it allows catalyst to be added and withdrawn from the reactor system semi-continuously. Since the density of the catalyst increases with time on stream, semi-continuous removal of catalyst from the reactor bottom permits discarding of catalyst which is significantly less active than the average material. Equally as important, there is no downtime on the system, other than that required by normal maintenance.

Internal Recycle. A second feature of the H-Oil process is internal recycle. Liquid oil, in equilibrium at reactor outlet conditions, is pumped back to the inlet and again passed through the reactor. This internal recycle creates a sink into which the large amounts of heat produced in the process are dissipated. The amount of recycle used depends on the charge stock and the amount of heat evolution. The cost of such internal recycle is very small because of the very low pressure head required.

Catalyst Poisons. The poisonous action of the organometallic compounds present in heavy oil feeds is ameliorated by staging of the catalyst. Catalyst staging is generally accomplished within a single reactor, with the second-stage catalyst on top of and separated from the first stage catalyst below. In this way, the cost of staging is minimal compared with its benefits.

Catalyst Life. The above features of the process have made it possible to operate with a long catalyst life without catalyst regeneration. If regeneration is to be avoided, a catalyst life of at least 10 bbl/lb (and preferably, of course, very much longer) must be attained. The H-Oil process has been able to provide this life even on very heavy charge stocks containing large amounts of organo-metallic impurities, and thus avoids complex and costly regeneration schemes.[3]

Catalyst Activity. The ebullated bed, internal recycle, and catalyst staging features of the H-Oil process make it possible to use very active catalysts of relatively small particle size. This permits operation of the H-Oil process with a much higher feed of oil per unit of reactor volume (and/or per unit of catalyst weight) than is possible with fixed bed processes which suffer from inherent pressure drop limitations.

Pressure. The operating pressure in the H-Oil process is markedly below that used in the old German slurry process. In general, operating on vacuum residuums, the H-Oil operating pressure is 3,000 psig providing a hydrogen partial pressure of about 2,250 psi. On lighter stocks, operating pressure is reduced to lower levels.

Space Velocity. As mentioned previously, the high activity of the catalyst in the H-Oil system permits a high space velocity, which, however, varies widely with the charge stock. For example, operating on furnace oils, a space velocity as high as 30v/hr/V may be used corresponding to 5.0 bbl/day/lb of catalyst and 130 bbl/day/ft^3 of reactor volume. Such high space velocities sharply decrease plant costs as compared with more conventional hydrogenation systems.

Operating temperature varies with the charge stock and with the degree of conversion (or hydrocracking) desired. When a high degree of conversion is desired, such as when processing heavy residuum stock, reaction temperatures are in the range of 800-850°F. However, when the operation is primarily to desulfurise and/or stabilize lighter charge stocks, lower operating temperatures are generally employed. Obviously, there is an interrelationship between operating pressure, space velocity, and operating temperature which defines the latter.

Hydrogen flow is substantially in excess of that consumed in the process. When operating on light gas oils for desulfurization and stabilization, hydrogen flow rates of the order of 1000 SCF/bbl of fresh feed are employed. However, in residuum processing at relatively high conversion, where the hydrogen consumption is of of the order of 1000 SCF/bbl of fresh feed hydrogen flows are considerably greater. The excess of hydrogen which is used in the H-Oil process allows the maintenance of adequate hydrogen partial pressure at the outlet of the reactor even though considerable quantities of hydrogen are consumed. Unconverted hydrogen is recycled back to the reactor.

It is considered that the H-Oil system, as described above, fulfills all of the requirements of a practical, and economic hydrogenation process. In the following section, pilot plant data are provided for various typical charge stocks which confirm the efficacy of the H-Oil process to achieve the ends desired in modern refinery practice.

PILOT PLANT DATA

Pilot plant data on the H-Oil process have been obtained at the Trenton laboratory of Hydrocarbon

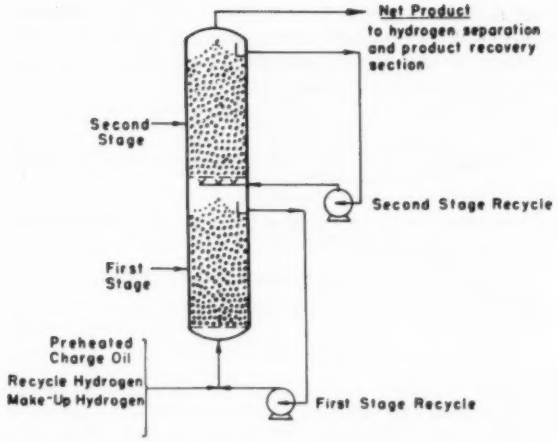
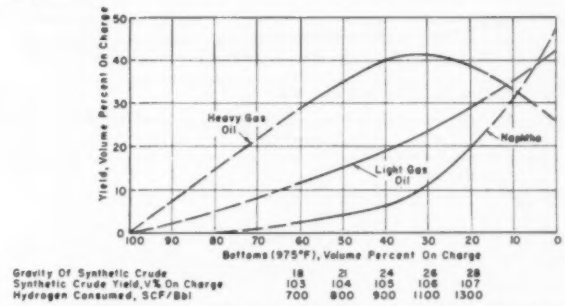


FIGURE 2—In this two-stage H-Oil process reactor, notice the upshot feed and recycle to each stage.



Gravity Of Synthetic Crude	18	21	24	26	28
Synthetic Crude Yield, V% On Charge	103	104	105	106	107
Hydrogen Consumed, SCF/Bbl	700	800	900	1100	1300

FIGURE 3—This product distribution was obtained when processing an 8° API Kuwait residuum. As severity increases, the yield of all distillate fractions increases until the catalytic feed fraction reaches a maximum and declines.

Research, Inc. since 1952. Over thirty different charge stocks have been evaluated in four pilot plant units varying in size from 1 gal/day to 25 bbl/day. Figure 2 schematically illustrates the reactor system.

In pilot plant runs, semi-continuous addition and replacement of catalyst was not practiced. Thus the data show the performance obtained on a constant charge of catalyst as the catalyst increases in age. These results are illustrative of, but obviously not the same as, those obtainable with "continuous" catalyst replacement. In general, for each charge stock, an economic balance must be made between the products obtained and the equilibrium catalyst activity (or catalyst replacement rate) to obtain such products. Such a procedure is fairly complex, with result depending on charge stock value, refinery design, product price structure, etc. For this reason catalyst replacement rates cannot be specified accurately and universally, and are indicated only approximately in the results which follow.

As demonstrated by the seven years of pilot plant operating history, process operability is excellent. Units have been operated continuously for long periods of time with no pressure drop difficulties. Catalyst weight balances have indicated no loss from the reactor within the precision of weight and analytical data.

H-Oil Processing of Residuums at High Conversion

In the deep H-Oil processing of heavy residuums, charge stocks of 5-15° API are converted to sweet synthetic crudes of 20-35° API. The degree of conversion depends on the product mix which is desired. Figure 3 illustrates the various products obtainable in the processing of an 8° API Kuwait vacuum bottoms.

As the severity of the H-Oil operation increases, the yield of all the distillate fractions increases concomitantly, with the yield of the catalytic feed fractions always higher than that of the furnace oil fraction, which is in turn always higher than that of the naphtha fraction. As conversion is increased further, the yield of the catalytic feed fraction reaches a maximum and then declines, while the yields of the furnace oil and naphtha fractions continue to increase. With still higher conversion to almost complete disappearance of bottoms, the yield of the catalytic feed fraction is severely diminished, with the remainder of the product being about equally distributed between furnace oil and naphtha.

It will be seen from Figure 3 that, as conversion increases, the API gravity of the over-all liquid product (i.e., the synthetic crude) increases simultaneously, as does the hydrogen consumption, and the over-all volumetric yield of liquid products. The most desirable level of conversion is that which consumes the lowest amount of hydrogen and simultaneously produces the most favorable product mix for the refinery. HRI experience indicates that this point generally corresponds to about 65-80 percent disappearance of the bottoms originally present in the charge, collateral with a hydrogen consumption of from 900 to 1,300 SCF/bbl with an increase in gravity between the charge stock and the synthetic crude of about 15-20 API units.

When the desired conversion level has been decided (generally by a refinery study), it is simple to operate the H-Oil unit at this level irrespective of operating catalyst activity. A small increase in temperature will compensate for lowered catalyst activity maintaining the yields of the individual product fractions at a predetermined and ostensibly optimum level.

However, maintenance of catalyst activity with respect to product quality is more difficult than maintenance with respect to hydrocracking severity. It has been found that deterioration of product quality primarily results from the deposition on the catalyst of metals that are present in the feed as soluble organometallic contaminants. Thus, the quantity of organometallic impurities determines, to a large extent, the catalyst consumption to produce a synthetic crude of a given quality. Catalyst activity decline is evidenced most obviously by the sulfur content of the over-all synthetic crude, which is thus used as a rough index of such deterioration; product gravity, although not as sensitive, may also be used to indicate such performance decline.

Figure 4 illustrates sulfur contents and gravities of the synthetic crude produced from single stage processing 8.3° API Kuwait residuum at a relatively deep conversion. This feed stock has a relatively high content of organo-metallic constituents (about 350 ppm of total ash). Operating single stage, product quality

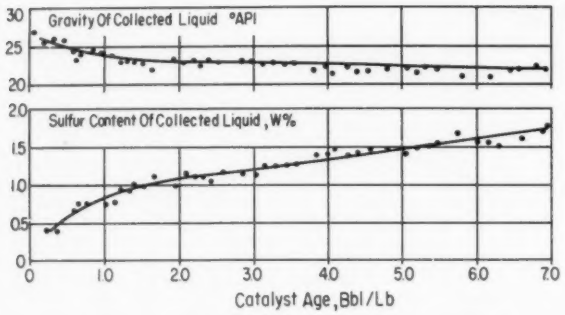


FIGURE 4—When single stage treating an 8° API Kuwait residuum, the gravity reaches an optimum at about 23.5 with the sulfur content at 1.0 weight percent.

(as indicated by the sulfur content and gravity of the synthetic crude in Figure 4) deteriorates throughout the run. In order to average a product quality corresponding to a sulfur content of 1.0 weight percent and a gravity of about 23.5, catalyst consumption would correspond to about 10-20 bbl/lb. This catalyst consumption, while not prohibitive, would represent a significant process cost.

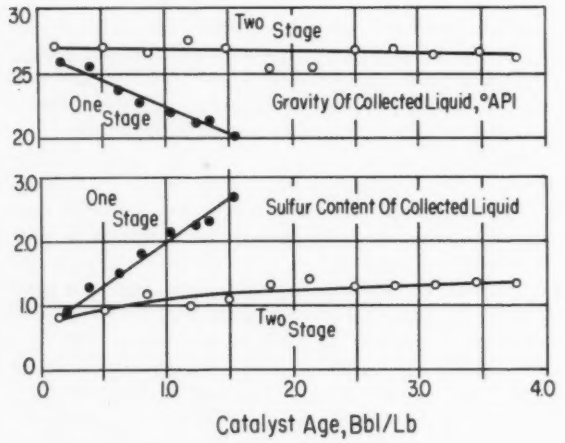


FIGURE 5—Shows the effect of catalyst poisoning when processing a 10° API Boscan crude. Black dots show single-stage treatment and circles two-stage treatment.

A more striking illustration of the effect of poisoning from organo-metallic constituents is shown in Figure 5. Here, results are shown for the H-Oil processing of 10° API Boscan crude. This crude is notorious for its content of organo-metallic constituents. It contains a total ash content of 2,400 ppm, and a vanadium content of 0.4 lbs. per barrel, the highest for any crude ever produced anywhere. The blackened points in Figure 5 illustrate one-stage H-Oil processing of this stock. Both the sulfur content and gravity of the synthetic crude product deteriorate rapidly, with the catalyst being virtually spent at an age of only about 2.0 bbl/lb. However, when the H-Oil unit is operated with reactor staging (open circles), the deterioration in performance is slowed down markedly, so that it is possible to attain a practical catalyst consumption rate even with this extremely poor charge stock.

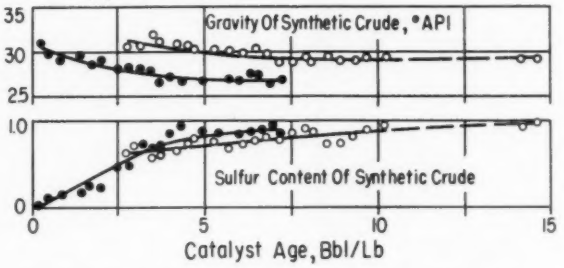


FIGURE 6—When processing a 11° API natural tar, as shown in these two runs, it can be converted into a 29° API synthetic crude containing 1.0 weight percent sulfur with catalyst utilization of 1—2 cents per barrel.

From the Boscan data, there is little doubt that staged operation will result in low over-all catalyst consumption costs for charging stocks containing a more reasonable content of metallic constituents. For example, Figure 6 illustrates the H-Oil processing of 11° API natural tar. This charge stock contains 750 ppm of organo-metallic constituents, intermediate between the levels in Kuwait residum and Boscan crude. The data shown are for two runs, with that illustrated by the open circles somewhat higher in over-all conversion than that shown by the darkened circles. In this case, the 11° API tar can be converted to a 29° API synthetic crude containing only 1.0 weight percent sulfur with an over-all catalyst utilization corresponding to 1-2 cents/bbl.

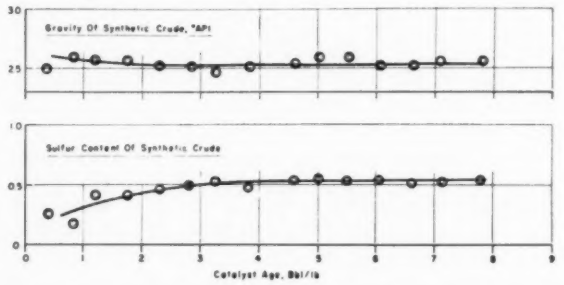


FIGURE 7—In this staged operation of a 17° API long sour residuum, containing a relatively small quantity of metals, essentially constant synthetic crude properties were observed after a small initial decline.

Figure 7 illustrates the application of the H-Oil process to a long sour residuum of 17° API gravity. Again, the process has been staged to minimize contamination due to organo-metallic impurities. In this case, the content of organo-metallic constituents is relatively small with only 80 ppm of total ash in the charge stock, and the desired extent of conversion (as delineated by refinery prescription in this case) relatively mild, so that operating pressure can be reduced and catalyst space velocity increased over cases shown previously. However, the important feature of Figure 7 is that in staged operation with a feed containing a relatively small quantity of metals, essentially no de-

terioration in the properties of the synthetic crude is observed after a small initial decline. Thus, in the case of such stocks, net catalyst utilization may be as low as 1 cent/bbl or less. Table 1 summarizes in greater detail the properties of the sour long residuum charge stock, and inspections on the synthetic crude and its derivative fractions by H-Oil processing.

To summarize, it is considered that the data provided above illustrate that the H-Oil process can upgrade the heaviest petroleum stocks with a depth of conversion corresponding to an increase in API gravity of about 15-20 API units. At this depth of conversion, about 60-80 percent of non-distillate material present in the charge will be converted to distillate products. Catalyst consumption will vary with the content of organo-metallic constituents in the feed; however, in the staged H-Oil system, most of the deterious effect of the organo-metallic constituents can be obviated.

H-Oil Processing of Heavy Gas Oils at Moderate and Severe Conversions

H-Oil processing of heavy gas oils is a relatively simple operation. Such heavy gas oils have a low or negligible content of organo-metallic constituents, and, since they contain more hydrogen than residuum stocks, have much less tendency to excessive coke formation. Thus, it is possible to operate the process at much higher temperatures than can be used with residuum stocks, to obtain as deep conversion of the gas oil as is required. In addition, it is possible to reduce operating pressure, and/or to increase space velocity, reducing plant capital costs over residuum operations.

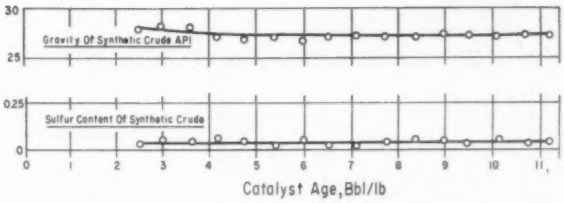


FIGURE 8—In preparing this 20° API deasphalter gas oil (DAGO) for catalytic cracking, constant performance was obtained over the entire run.

Figure 8 illustrates the application of the process charging a 20° API deasphalter gas oil (DAGO). This stock is of course not a true distillate and, in this sense, it simulates the heaviest and the most metallic-containing gas oil which could possibly be charged to the process. The work carried out as shown in Figure 8 was at relatively low severity, since in the application under consideration, it was desirable to convert the DAGO to feed for subsequent catalytic cracking, rather than directly to furnace oil and naphtha. As shown in Figure 8, no deterioration in performance was observed over the entire length of the run. These data indicate the likelihood of a catalyst consumption of the order of 100 bbl/lb when processing DAGO or similar charges.

Table 2 summarizes the DAGO operation in greater detail. This table attests to the marked improvement in the quality of the product fractions obtained from the H-Oil operations, as compared with the quality of similar fractions in the charge stock.

Table 3 summarizes H-Oil operating data on a virgin Kuwait vacuum gas oil at relatively deep conversion. No deterioration in results was observed over the operating period. As shown in Table 3, a unique aspect of the results was the extremely high ratio of distillate fuel oil (furnace oil and kerosine) produced relative to naphtha. Such relatively high yields of distillate fuel oil cannot be obtained from catalytic cracking. This feature is extremely attractive in many markets throughout the world where the demand for distillate fuel oils has outpaced the demand for gasoline.

H-Oil Processing of Light Gas Oils

As in operations on heavier stocks, the H-Oil system for processing light gas oils utilizes upshot operation with an ebullating bed. The advantages of the system may be seen by comparison with conventional distillate

TABLE 1—H-Oil Processing of Long Residuum Average Product Properties Over Age of 40 BBL/LB

	Charge Stock	Product
Synthetic Crude, C_4+		
Gravity, °API	16.8	26
Sulfur, Weight Percent	2.54	0.5
Ramsbottom Carbon, Weight Percent	8.6	3
Yields, Percent on Charge		
C_1–C_3, Weight Percent		1
C_4–400 °F, Volume Percent		9
400–650 °F, Volume Percent	6	22
650–975 °F, Volume Percent	53	53
975 °F+, Volume Percent	41	20
C_4+ Liquids, Volume Percent	100	104
Inspections on Fractions		
Naphtha, C_4–400 °F		
Gravity, °API		60
Sulfur, Weight Percent		0.1
Furnace Oil, 400–650 °F		
Gravity, °API	29.1	32
Sulfur, Weight Percent	1.46	0.1
Diesel Index	43	46
Catalytic Feed, 650–975 °F		
Gravity, °API	22.1	24
Sulfur, Weight Percent	1.91	0.4
Diesel Index	40	45
Ramsbottom Carbon, Weight Percent	0.5	0.4
Heavy Fuel, 975 °F+		
Gravity, °API	9.0	14
Sulfur, Weight Percent	3.26	1.1
Ramsbottom Carbon, Weight Percent	18.4	14

TABLE 2—H-Oil Processing of 19.9° API DAGO Average Product Over Age of 40 BBL/LB

	Charge Stock	Product
Synthetic Crude, C_4+		
Gravity, °API	19.9	27
Sulfur, Weight Percent	1.12	0.03
Ramsbottom Carbon, Weight Percent	2.9	0.7
Nitrogen, Weight Percent	0.17	0.1
Metals, ppm		
Vanadium	1.8	0.1
Nickel	2.4	0.4
Yields, Percent on Charge		
C_1–C_3, Weight Percent		1
C_4–400 °F, Volume Percent		8
400–650 °F, Volume Percent		16
650–975 °F, Volume Percent	18	38
975 °F+, Volume Percent	82	41
C_4+ Liquids, Volume Percent	100	103
Inspections on Fractions		
Naphtha, C_4–400 °F		
Gravity, °API		57
Sulfur, Weight Percent		
Furnace Oil, 400–650 °F		
Gravity, °API		34
Sulfur, Weight Percent		
Diesel Index		50
Catalytic Feed, 650–975 °F		
Gravity, °API	21.0	24
Sulfur, Weight Percent	1.01	0.03
Ramsbottom Carbon, Weight Percent	0.3	0.2
Diesel Index	42	49
Heavy Fuel, 975 °F+		
Gravity, °API	19.1	24
Sulfur, Weight Percent	1.16	0.04
Ramsbottom Carbon, Weight Percent	3.4	1.6

TABLE 3—H-Oil Processing of Kuwait Heavy Gas Oil

	Charge	C_4+ Product	C_4–400 °F	400–650 °F	650 °F+
Volume Percent	100	103.8	22.5	60.2	21.1
Gravity °API	22.9	36	60	33	26
Sulfur, Weight Percent	1.72	0.11	0.06	0.09	0.22
Bromine No., cgs/gm			11	8	
Aniline Point, °F			128	144	
Diesel Index				48	
Reid Vapor Pressure, psi			7		
ASTM Gum, mg/l			2.0		
Octane Rating CFRR					
Clear			50.9		
+3 cc TEL			70.4		

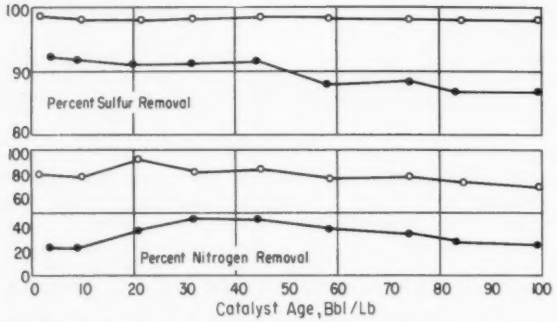


FIGURE 9—Typical performance at 1,100 psig (without catalyst addition) on a furnace oil feed containing straight run, catalytic cycle and coker light gas oils. Open circles show space velocity of 5 V/hr/V and dots 30 V/hr/V.

treating processes which prevalently utilize downshot, fixed bed reactors.

Because of the absence of pressure drop limitations the catalyst employed in the H-Oil process is of smaller particle size and more active than in conventional fixed bed processes. Thus, reactors are smaller and the quantity of catalyst charged much less than in such conventional processes.

Daily withdrawal of spent catalyst and addition of fresh material maintains performance essentially constant. This has three important results; 1) the quality of the finished furnace oil is constant, making it possible for a refiner to guarantee a product of fixed specifications, rather than the variable product produced from conventional refining operations, in which quality swings widely depending on whether the catalyst is relatively fresh or spent; 2) "continuous" replacement of catalyst leads to a net catalyst consumption only 30-50 percent of that in conventional fixed bed systems; 3) downtime is reduced to that required for maintenance.

The H-Oil system has several operating advantages. It is immune to pressure drop difficulties due to corrosion and scaling which have plagued fixed bed systems. In addition, if an operating error or mishap occurs (such as, for example, loss of the hydrogen recycle compressor) the catalyst inventory which must be discarded is much less than in fixed bed systems. Local overheating from channelling is virtually impossible in the ebullating bed H-Oil system.

In most cases where furnace oil treating is required, it seems preferable to design the H-Oil system at a total pressure of about 1,500 psig. Due to the much higher oil throughputs which are obtained, capital costs are essentially unchanged over lower pressure operations. Nitrogen removal is considerably improved at a given level of desulfurization. Catalyst inventory is only 10-20 percent of that in conventional systems. More importantly, the furnace oil unit designed at 1,500 psig has considerable flexibility with respect to substitution of heavier feeds, and anticipates the more stringent requirements of tomorrow with respect to furnace oil quality.

Stocks in the furnace oil boiling range investigated at Trenton include virgin, catalytic and coker light gas oils. Effects of the operating variables have been comprehensively established. Data have been obtained to a catalyst life in excess of 100 bbl/lb, so that catalyst replacement rate is known with good accuracy.

Figure 9 illustrates typical H-Oil performance at 1,100 psig (without catalyst addition) on a furnace oil feed containing straight run, catalytic cycle and coker light gas oils. This charge stock contains about 1.0 weight percent sulfur and 300 ppm nitrogen. At a fresh feed space velocity of 30 V/hr/V, sulfur and nitrogen removal average 90 percent and 30 percent respectively. At a fresh feed space velocity of 5 V/hr/V, sulfur removal approaches 99 percent with about 80 percent nitrogen removal. Deterioration in performance is insignificant over a catalyst age of 100 bbl/lb.

UTILIZATION

Preliminary economics for the H-Oil process have been provided in the previous publication. Numerous applications offer attractive payouts. Those which have been studied in detail include:

1. The processing of Mid-Continent residuum (together with catalytic slurry oil and any other heavy fuel oil discards which may be available) by a relatively small refinery to eliminate a heavy fuel oil problem. In this case the H-Oil plant would be about 5,000 B/D in capacity and would utilize hydrogen which has only fuel value.

2. The processing of a long sour residuum in a large refinery which has been handling mostly sweet crude. In this case, the H-Oil plant permits the substitution of cheaper heavier sour crude without any increase in No. 6 fuel production and with no additional bottoms handling equipment necessary.

3. The field processing of a heavy sour crude at a site where the market for heavy fuel oil is poor. In this case, hydrogen is produced from the heavy ends of the H-Oil product.

4. The processing of a heavy coker gas oil where cracking regenerator capacity is limiting.

5. The deep processing of a heavy gas oil where furnace oil commands a premium.

The above listed possibilities for H-Oil do not include more obvious uses such as desulfurization of light gas oils, heavy distillates, heavy fuel oils, etc. There are other interesting possibilities for new refineries which may be designed without catalytic cracking.

The economics provided in the previous publication may be considered as illustrative of earlier work. In addition to improvements in the process itself, new designs provide for lowered costs for producing hydrogen when needed for H-Oil processing. Typical investment and operating cost data have been derived for many applications and are generally available on request.

ACKNOWLEDGMENTS

Direction of the development described herein was given by P. C. Keith and E. T. Layng. E. S. Johanson and M. Sze contributed greatly to the fundamentals of the process as finally developed. Contributing to the execution of the laboratory program were S. B. Alpert, A. R. Robb, and E. R. Ludwig. Engineering process studies were carried out principally by A. Strum and J. F. Campagnolo. Thanks are due to Nalco Chemical Co. and American Cyanamid Co. for supplying catalysts used in the work.

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Which to use . . .

Relief Valve or Rupture Disc?

The main difference is obvious—one will reseat and other will not. The question is—where to use one or the other and when to use both?

Peter A. Puleo, Industrial Process Equipment Company, St. Louis, Mo.

THE PROBLEM is which to use, a rupture disc or a relief valve.

Or when should both be installed?

The answer is not too difficult if the operator will compare the functioning of each as well as the effects of their use in a given process.

And that comparison is the purpose of this discussion.

The physical difference is obvious—one will reseat and the other will not.

In many continuous processes, rupture disc applications are limited because of the loss of priceless fluid after the disc has ruptured. In some cases, this may point to the preferential use of a relief valve. Usually a rupture disc lends itself to wider application in batch processes where it is used on tanks and reactor vessels.

The second principal difference is the type of pressure rise that is expected. A gradual pressure rise, such as a thermal expansion, can be relieved by either a relief valve or a rupture disc. Both may be used and in many cases they are used together.

A difficult situation occurs when the pressure rise is extremely rapid, approaching explosive conditions. A relief valve may not respond quickly enough because of the spring inertia which must be overcome. Furthermore, excessive capacity caused by an explosion may not be adequately handled by a relief valve unless it is impractically large. Normally a relief valve is not sized to cope with explosions. The positive venting of a rupture disc makes it definitely superior to a relief valve in explosive situations and for this reason rupture discs are often referred to as explosion discs.

Frequently a rupture disc and relief valve will be used in parallel to protect a vessel against either gradual pressure buildup or an explosive condition (Figure 1). The relief valve is used as the primary relieving device to handle gradual pressure rises and small relief loads. The rupture disc usually is set at a higher pressure than the relief valve. It will protect the system from extremely rapid pressure rises approaching explosive force.

System Factors Affecting Rupture Disc and Relief Valve Performance. Among these factors are the geometry of the system, temperature, viscosity, back pressure, pulsation, crystallization, slurries, specific gravity and corrosion.

The geometry of a system refers to the relative dimensions of a vessel or system. For example, in the case of a pipe line, where length is considerably greater than the diameter, special problems are involved in applying pressure relieving devices. A relief valve will have wider application over a rupture disc in a pipe line, because in most cases only gradual pressure buildups can be relieved. An explosive condition in a pipe line is very difficult to relieve because the pressure may not be transmitted quickly enough to the relieving device. Actually, it is very difficult to design emergency relieving requirements for a system of this type.

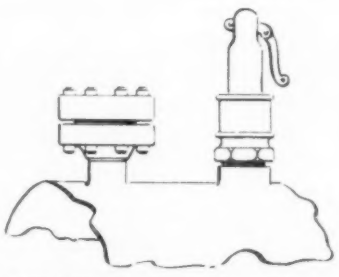

FIGURE 1—Relief valve and rupture disc in parallel protect against explosion.

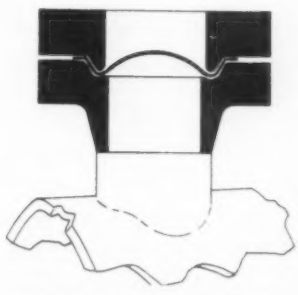

FIGURE 2—Rupture disc location for highly viscous fluid systems.

Relief Valve or Rupture Disc?

Another difficult system is the long and slender distillation column. Rupture discs have been used for column explosion protection by spacing them along the entire length at intervals aproximately equal to the diameter of the column. This is usually adequate to handle an explosive condition.

The system temperature has a more direct effect on a rupture disc than on a relief valve. A high temperature has a weakening effect on the rupture disc so that its rated bursting pressure will be lowered. All rupture discs must therefore be specified to relieve at a certain temperature. Maximum temperature limitations exist for each of the various materials from which discs are made. This is done in order to obtain reliable bursting pressures. Special designs are also available to accommodate certain high temperature applications.

With regard to a relief valve, however, the temperature should also be taken into account in its performance. Temperature affects spring tension as well as the capacity changes for the fluid through the relief valve.

The viscosity of a fluid will generally have more effect on the performance of a relief valve than a rupture disc. Viscosity affects fluid flow in the valve relieving passages and mechanisms as compared to the free opening ruptured discs. Special relief valve designs are offered to serve in high viscosity applications.

When using a rupture disc in a highly viscous fluid system, care must be taken that the rupture disc is placed as close to the flowing medium as possible (Figure 2). To be effective, the disc should not be placed at the end of a long line or *away* from a vessel.

Back Pressures and Vacuum. In the case of a rupture disc under uniform back pressure, the disc will be set to relieve at the net differential pressure with the higher pressure under the disc. If the back pressure or vacuum in the system should be excessive or of a varying nature, exerting a higher pressure on the top side of the disc, a vacuum support should be used so as not to buckle the disc and therefore weaken it.

The effect of a constant back pressure on a relief valve can be handled by a suitable spring so that the valve will relieve at the net differential. Under varying conditions of back pressure, however, the problem becomes more complex and makes it difficult for the valve to relieve at a preset point. To compensate for these effects, valves are available with a balanced piston or balanced bellows.

Pulsations. First, you should differentiate between gradual pulsations and sharp pulsations. Either device can be safely used under gradual or infrequent pulsating conditions. In this case, it is recommended that a rupture disc be set to burst at approximately 100 percent over the normal operating pressure. Usually the bursting pressure is set at 50 percent above normal operating pressure in non-pulsating systems. Pulsations tend to weaken a ruptured disc especially if these pulsations are continuous. Very gradual pulsations will not greatly affect the operation of relief valves as long as the variations do not approach the set pressure too closely.

Sharp pulsating conditions may cause a relief valve to rapidly slam open and shut and possibly damage the valve. Under these conditions, neither a relief valve nor a rupture disc may respond to a rapid peak pulsation pressure. It is very difficult to predict performance of relieving devices under extreme pulsation intensities. Each case should be considered individually and discussed with the manufacturer's technical representative. The fluid phase of the system, whether it be gas or liquid, has essentially no effect on the use of a rupture disc. A relief valve, however, is usually designed differently for gas services than for liquid services. It has been noted, that when a relief valve designed for gas service is used in liquid applications, excessive chatter is encountered.

Crystallization of process fluids present a problem to relieving devices. Crystallization of solids under a relief valve may render it inoperative. A liquid seal can be

TABLE 1—Minimum Rupture Pressures

Base Temperature 72°F.; 20°C.

Disc Size	Aluminum	Aluminum Lead Lined	Copper	Copper Lead Lined	Silver	Platinum	Nickel	Monel	Inconel	321 or 347 Stainless
¼	310	405	500	650	485	500	950	1085	1550	1600
½	100	160	250	330	250	250	450	530	775	820
1	55	84	120	175	125	140	230	265	410	435
1½	40	60	85	120	85	120	150	180	260	280
2	33	44	50	65	50	65	95	105	150	160
3	23	31	35	50	35	45	63	74	105	115
4	15	21	28	40	28	35	51	58	82	90
6	12	17	25	25	24	26	37	43	61	70
8	9	19	35	35	27	...	30	34	48	55
10	7	16	42	42	...	...	47	28	.....	45
12	6	10	55	55	...	...	...	360	.....	45
16	5	8	55	55	...	...	...	270	.....	33
20	3	8	70	70	...	...	...	215	.....	27
24	3	8	60	60	...	...	...	178	.....	65
Maximum Recommended Temperature	**250° F 120° C**	**250° F 120° C**	**250° F 120° C**	**250° F 120° C**	**250° F 120° C**	**600° F 320° C**	**750° F 400° C**	**800° F 430° C**	**900° F 480° C**	**600° F 320° C**

installed to take care of this situation. This condition will also exist when a material tends to coagulate or solidify building up a cake underneath the relief valve.

The crystallizing and building up of solids on the underside of a rupture disc may not affect its operation as greatly as a relief valve. Relatively dependable performance can be expected from a rupture disc even when material has collected on either side as long as the caking of the material is not excessive. In many applications, rupture discs are used below a relief valve in series to protect the relief valve from such inoperation (Figure 3). In this case, a rupture disc is designed for the same pressure at which the relief valve is set. However, the relief valve may also be set at a lower pressure than the rupture disc. This is done in order to increase the capacity of a given valve size or in case the function of the relief valve is merely to close the vent after the pressure has been relieved. This practice has been considred less expensive than a liquid seal.

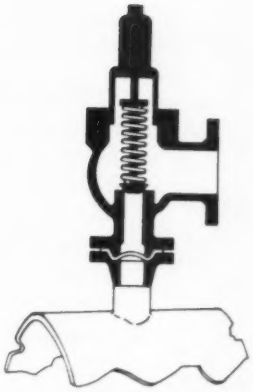

FIGURE 3—Protect relief valve from caking-up by putting rupture disc below it.

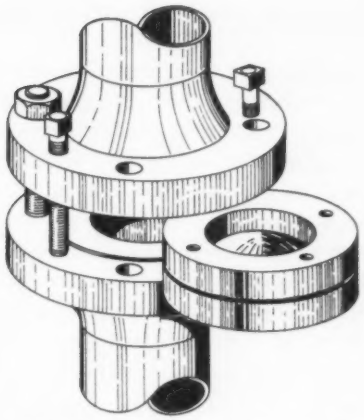

FIGURE 5—Jack screws are used to remove discs from piping flanges.

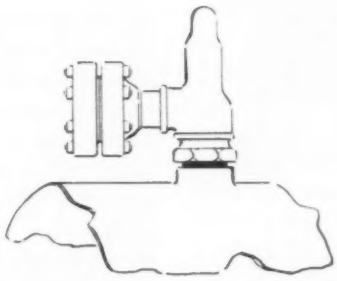

FIGURE 4—Rupture disc downstream prevents relief valve leakage.

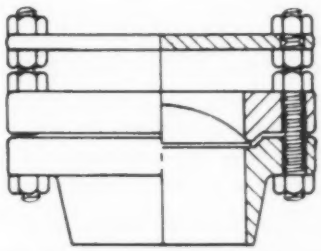

FIGURE 6—A baffle plate prevents damage when disc bursts.

In liquid slurry conditions, a rupture disc will perform more dependably than a relief valve. The problem here is similar to that of a viscous liquid. A slurry may clog the operating parts of the relief valve. A relief valve can be flushed after each opening to clean out the bonnet and seating area of any solids. A guideless design such as a diaphragm relief valve can minimize the clogging by a slurry. Other valve designs have also been developed for slurry conditions to minimize clogging. Relief valves have been used, for example on a particular coal slurry application, with slurry concentrations as high as 60 percent pulverized coal. There are three pumping stations over a 150-mile pipe line with five 4 x 6-inch valves per station. These valves are operated at 1,500 psig and are required to open daily because of possible slugging of the coal particles.

The specific gravity of a fluid has little or no effect on the operation of either a rupture disc or a relief valve. Its only effect will be in the relieving capacity of the device and should be taken into account in the sizing calculation of the valve or rupture disc.

The corrosive effects of a system will naturally affect the operation of both a relief valve and rupture disc. Rupture discs are available in a great variety of metals with little or no difference in cost between them except for precious metals. Furthermore, rupture discs are available in the newer plastic linings or can also be made of pure carbon materials. Relief valve designs are also available in plastics such as PVC. The plastic parts on the valve are those in contact with the fluid. Under corrosive conditions it is commonly found that rupture discs are sometimes used beneath the relief valve to protect it from inoperation caused by corrosion. The rupture disc will generally be far more practical in extremely corrosive conditions.

DESIGN FACTORS

Leakage. Consideration should be given to the problem of leakage in the selection of relief valve or rupture discs. For almost zero leakage, a rupture disc should be considered, since it is almost impossible to obtain a relief valve with no leakage. In many cases, rupture discs are used beneath the relief valve to prevent leakage through the valve, or downstream from the valve to prevent leakage past it (Figures 3 and 4).

Relief valves can be obtained with a minimum leakage tolerance. To check leakage of relief valves, most

manufacturers use a method of connecting a tube to the valve discharge, with the other end of the tube submerged in water. The valve is brought up to 90 percent of its pressure setting and the number of air bubbles escaping the valve are counted. This bubble count is then expressed as cubic feet per day of leakage. Standard specifications, procedures and methods are now being discussed by manufacturers on establishing various grades of tightness standards through the auspices of the American Petroleum Institute.

By further lapping of the relief valve seat and disc, leakage can be reduced considerably. Valves with a leakage of 0.2 cubic feet per day or less are available. An additional charge is usually made for minimum leakage specifications.

Another factor which will affect the leakage of relief valves is temperature. With an increase in temperature, the viscosity of a fluid is lowered so that more leakage can be expected. This is particularly true of a gas. Furthermore, should the temperature be high enough, the disc and seat can warp thereby increasing the leakage possibility. It may be interesting to note that less leakage has been found in larger valves than on smaller valves. The larger seating area of a large valve generally reduces leakage. Larger valves also have less leakage because alignment of the parts is not as critical as it is in small valves.

Pressure Limitations. Both relief valves and rupture discs have pressure setting limitations. On the low pressure side, relief valves generally have a minimum pressure setting in the area of 5 psig. Lower pressures are sometimes available in specially designed valves. Rupture discs have a limit on a minimum rupture pressure for which a disc is available and will vary with the size and type of metal. An example of this is shown in Table 1. It is noted that among the various metals, aluminum and copper, for example, the minimum pressure rating is lower than in the stronger metals such as stainless steel. Also, a larger disc size will have a lower minimum bursting pressure. Recently, discs of stronger metals have been designed with very low minimum bursting pressures at a higher disc cost. These are made up of multiple component discs and utilize a plastic seal membrane as the principal pressure relieving element. These new designs have been able to withstand greater pulsating conditions and also higher temperature applications. Here too, the minimum pressure will be smaller in the larger sizes. Carbon discs are also available with very low bursting pressures.

Concerning maximum pressures, there is practically no limit to the relieving pressures available for rupture discs or relief valves. These devices have been known to be manufactured for applications as high as 100,000 psig. Special relief valve designs must be considered for these extremely high pressure settings.

Pressure Settings. In adjusting pressure settings, relief valves have a definite advantage over the rupture discs. Generally speaking, relief valves can be adjusted plus or minus 10 percent from the manufacturers set pressure. Wider adjustments can be obtained within a particular spring range but this practice is restricted by the ASME Unfired Pressure Vessel Code. However, a heavier or lighter spring can be installed in the relief valve as long as the body rating is not exceeded. The rupture disc on the other hand, is designed for only one pressure and no adjustment can be made.

The relationship of operating pressure to the relieving pressure is important both to the relief valve and rupture disc. As noted previously, the rupture disc is generally recommended to be set at 50 percent above the operating pressure in non-pulsating conditions, and 100 percent in pulsating conditions. This is of particular disadvantage where a pressure vessel is to be designed so that the operating pressure is closer to the design pressure than is allowed with rupture discs.

According to the code requirements, a relief valve cannot be set to relieve higher than the vessel design pressure, when it is used as the primary relieving device. Additional or secondary relieving devices can, however, be installed for protection against fire and may be set 10 percent above the design pressure. A minimum difference of 10 percent between working pressure and valve setting is strongly recommended. It is usually desirable that the operating pressure be considerably below the pressure setting of the relief valve in order to prevent leakage and also so as not to weaken the spring, especially at high temperatures.

The relieving accuracy of a rupture disc and a relief valve differ somewhat. Manufacturers of rupture discs state that discs will have a relieving accuracy of plus or minus five percent of the bursting pressure. This is also a code requirement.

The relief valve on the other hand will have considerably lower relieving accuracy. The code allows a tolerance on relief valve settings generally of plus or minus 3 percent. An accuracy of 1 percent can be obtained when the adjustment is made on the installation. The relieving accuracy of a relief valve is generally dependent on the spring pressure range, and as long as this range is small and not over extended, the effect on accuracy by the spring range will be negligible.

The relieving capacity of a rupture disc will be determined to a large extent by how completely the rupture disc opens up. This will be its full diameter in case of an explosion. The relief valve capacity is based upon the seat area, but will also be governed by the design

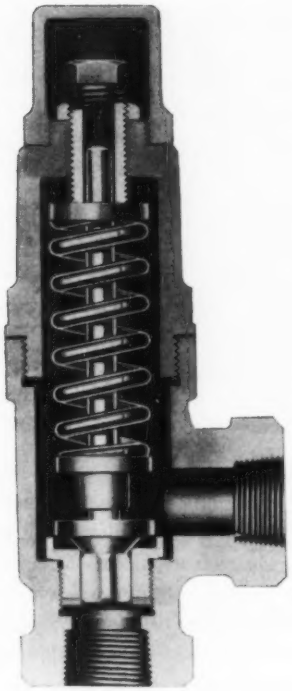

FIGURE 7—Bottom guided valves have wing guides on inlet side.

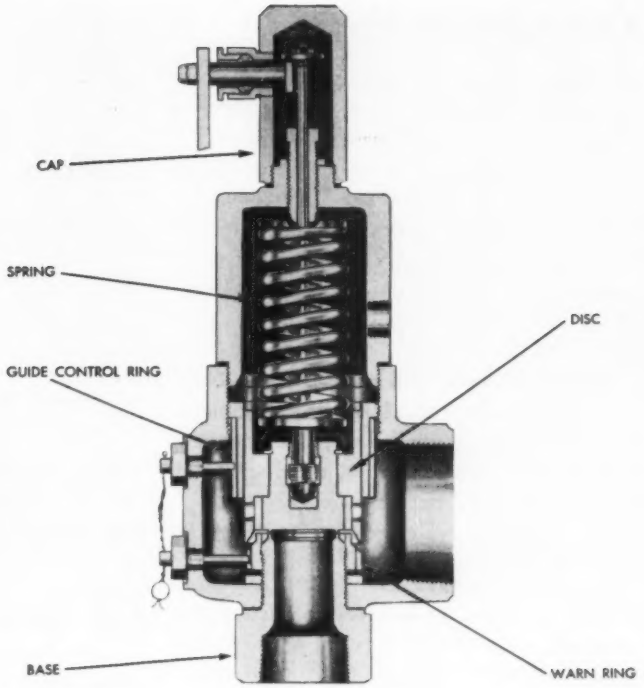

FIGURE 8—Top guided valves are generally of the nozzle type.

of the flow passages. The size of either relieving device will generally be determined by the relieving capacity required for each application. This is sometimes very difficult to do in the use of rupture discs. Capacity tables are provided by the manufacturer for various conditions and fluids.

The piping to a relieving device should never be smaller in diameter than the diameter of the device itself. This is a code requirement. Furthermore, the relieving device should be placed as close to the source of pressure as is practically possible.

In selecting rupture discs, a few additional considerations should be taken into account. **Fragmentation** of the rupture disc may damage equipment if it is blown downstream. This is particularly true of carbon or plastic discs which tend to shatter on rupturing. Metal rupture disc designs are available to minimize this possibility. Fragmentation will damage a relief valve, for example, if it is placed below the disc. By properly designing a rupture disc application, this possibility can be minimized.

Downstream piping designs should be studied for the venting of a system where a rupture disc is to be installed. If the downstream piping is small and of substantial length, the resistance to flow of a fluid may be great enough to damage the piping or equipment. In one such case, a reaction vessel was processing viscous materials. In the process of an unexpectedly violent reaction the rupture disc opened up, but the frictional resistance in the downstream piping was large enough to hold up the pressure and damage the vessel. Downstream piping should be large enough to accommodate the maximum flowing conditions of the system. This point should also be taken into account on relief valve applications.

Changing rupture discs sometimes presents an inconvenience. This is not a problem when the disc is in a free opening flange assembly. But when the disc is attached to downstream piping, which is rigidly fastened, the problem of changing discs is present. This is particularly true in large diameter piping where the weight of the flanges may make it difficult to remove the disc. Jacking arrangements of many designs can be applied (the simplest type uses jack screws in the flanges, Figure 5). Thus, the disc flanges can be jacked apart sufficiently to insert a new rupture disc.

Recently designed rupture disc flanges permit very rapid changing of a rupture disc, by using a flat base and flat holddown flange. These have smaller outside diameters that fit within the boltcircle of the mating flanges. They can be removed without taking out all of the flange bolts. Quick replacement of the disc can be made at a convenient location and then the assembly is reinserted into place.

Use of Baffle Plates. When placing a rupture disc assembly on the end of a horizontal cylindrical vessel, it is possible for an explosion to occur which will move the vessel from its foundation pads. This has been experienced in long cylindrical wood treating vessels. A baffle plate can be installed on the discharge side of the

rupture disc flange assembly to minimize this possibility (Figure 6). These baffle plates can also be used to prevent damage to nearby equipment. The baffle will in this case act as a deflecting device moving the fluid radially.

Drain Connection. Where a rupture disc assembly is vented to atmosphere, consideration should be given to the possibility of rain or moisture condensing and accumulating on the top of the disc. A simple drain connection can be obtained with the assembly to remove any such accumulations. If there is a possibility of much ice forming because of freezing conditions, heat of some sort should be applied to the disc. Otherwise, a small amount of ice on top of the disc should not greatly affect its rated bursting pressure.

Relief Valve Selection. Two basic designs are the bottom guided and the top guided valves. Bottom guided valves have wing guides in the bore of the valve on the inlet side attached to the disc (Figure 7). Vapor valves of this type are provided with a control ring to adjust the valve for a clean pop and blowdown. Liquid valves generally do not have a control ring.

Top guided valves in which the disc is guided from the top on the downstream side, are generally nozzle type valves (Figure 8). This type can be further divided into one ring and two ring designs. The one ring valve has a single ring on the seat to control both pop action and blowdown. The two ring valve has a ring for each of these functions. The seat ring is normally called the warn ring and controls the pop action. The control ring located on the disc controls the blowdown.

Blowdown. The blowdown characteristic of a relief valve is very important in many applications. Blowdown is described as the pressure below the actual set pressure at which the valve fully reseats after it has blown open. This pressure is usually expressed as a percent of the relieving set pressure and will normally average 4-5 percent, the latter being the ASME code requirement. By appropriate adjustment of the seat or disc ring, this value can be set as close to 2 percent, depending upon the valve design. It should be noted, however, that a lower blowdown will tend to increase leakage in a valve, so that this factor must be evaluated in the relief valve installation.

The lifting characteristic of a relief valve depends on the basic valve design. This characteristic is only important in its effect upon the capacity of the valve. Bottom guided valves are sometimes described as low lift valves. The lift of these valves is generally one-fifteenth to one-tenth of the seat diameter. Nozzle valves are termed high lift valves, lifting about one-fourth of the throat diameter or more.

Piping Strains. The possibility of piping strains should also be studied in designing relief valve installations. The piping strain can affect the relieving pressure and can cause seat leakage because of the distortion of the valve body. Where extreme piping strains are encountered, rigid materials of construction should be used, or the piping should be adequately supported. The valve should be equal to or better than the piping specifications.

Bellows Seal. Relief valves with bellows seals separate the process fluid from the top works of the valve. These bellows are used to protect the guiding surfaces from fluids which may otherwise render the valve inoperative or to compensate for variable back pressures. Although the bellows does prevent leakage of fluid to the atmosphere, a bellows is not required for this purpose.

Bonnet Cap. Relief valves are available with a simple cap on the bonnet to protect the adjustment screw. This cap is available with or without a lifting lever. In the lever design, the cap can be provided with a packed arrangement so as not to leak any of the fluid through the top of the valve.

Spring Setting. Another important consideration which should be taken into account in using relief valves, is the setting of the spring. After a period of time, especially in high temperature applications, a relief valve provided for a certain set pressure may change its pressure setting. This setting will drift to a lower level because of the lowering of the spring tension. All relief valves have this characteristic. Actually this may not be injurious to the system since it will cause the valve to open at a lower pressure which is better than the reverse condition. If a relief valve pops too often, the setting should be checked to see if it is too low.

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About the Author

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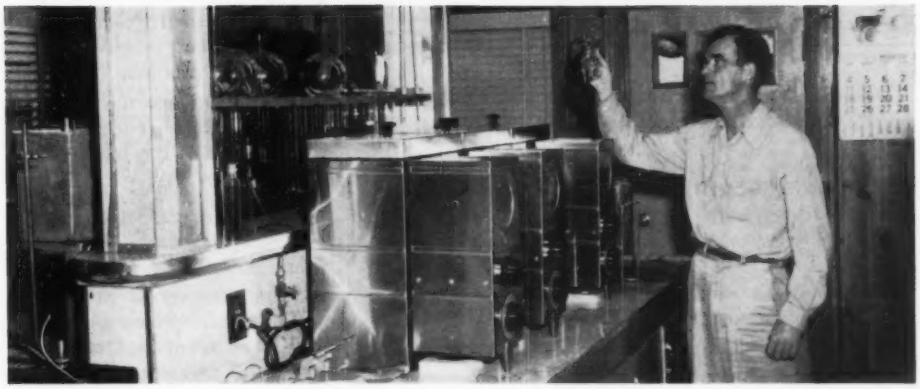

FIGURE 58—Testing helps operator run the plant to meet product specifications.

Operator's Handbook for Gasoline Plants

PART 12–Plant Testing and Water Treating: Final part of a series that simplifies operations and equipment for the new and experienced operator

Manufacturing Department
Tennessee Oil Refining Company
A Division of Tennessee Gas Transmission Co., Houston

PLANT TESTING and water treating are two auxiliary functions that every operator should understand to make a plant work properly.

PLANT TESTING

Tests for product properties are an important aid to the operator in running the plant to meet product specifications. These tests are outlined in detail in ASTM and NGAA manuals. The ASTM manual is entitled "ASTM Standards on Petroleum Products and Lubricants" and is published by the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. The NGAA manual is entitled "Plant Operations Test Manual" and is published by the Natural Gasoline Association of America, 421 Kennedy Building, Tulsa 3, Okla. Since these tests are fully described in the respective manuals, only the purpose and results of each test are outlined here. Table 3 gives a complete guide to testing by products.

Commercial Propane Residue. This test provides a simple, rapid means for obtaining the hydrocarbon residue after weathering to the melting point of mercury. The hydrocarbon residue is a measure of the butanes and heavier contamination. It can be used by the plant operator as a guide for controlling plant operations to produce a specification product.

The results are reported in volume percent as butane contamination (Mercury Freeze Method, NGAA Test).

Commercial Propane Dryness. Moisture in commercial propane may cause operational difficulty in equipment or manufacturing processes used by the consumer. For example, a customer using commercial propane for cooking and heating may experience pressure regulator freeze-up in cold weather if the moisture content is too high. A chemical manufacturer may find that the processes, where commercial propane is the feed stock, may not be operative or efficient if too much moisture is present.

Moisture is reported as the dew point temperature in degrees Fahrenheit. (Dew Point Method, NGAA Test.)

LPG Weathering. This test is for the determination of the initial boiling point and the end point of propane and butanes. It is used by the plant operator as a guide for controlling plant operations for production of a specification product.

For plants without a means of analyzing production streams readily, this method most economically points the way to operational pressure and temperature changes required to maintain a specification product. This method makes use of an electrical temperature recorder to pinpoint deviations from the pure boiling points of propane, isobutane, normal butane, and various combinations of these compounds. This test is similar to the NGAA Weathering Test for Butane and Butane-Propane Mixtures except the glass thermometer is replaced with a thermocouple connected to a temperature recorder.

Deviation from the true boiling point is reported in degrees Fahrenheit.

LPG Specific Gravity. This test is a simple, rapid means of determining the specific gravity of liquefied petroleum gases, or other volatile hydrocarbon products, at 60° F.

The results are expressed as a dimensionless fraction, since specific gravity is a ratio of the weight of LPG to water. (Pressure hydrometer method, NGAA Test.)

LPG Corrosion. This test determines whether the LPG contains any material of a corrosive nature. Although sulfur compounds are the materials which usually cause the mixture to be corrosive, it is not necessarily limited to sulfur compounds. This test is rapid and can be used by the plant operator as a guide for controlling this phase of plant operations.

The results are reported as 1, 2, 3, or 4 depending upon the standard to which the discoloration of the copper strip most nearly conforms. (Copper Strip Method, ASTM D-130-56.)

Chlorine in Gaseous Hydrocarbons. This test rapidly determines small amounts of organic chlorides dissolved in butanes or other volatile hydrocarbons.

Results are reported in percent by weight of chlorine. (Lamp Combustion—Votocek Titration Method, L. H. No. 607 from "Light Hydrocarbon Analysis," Rheinhold Publishing Co.)

LPG Vapor Pressure. This test determines the gage vapor pressure of liquefied petroleum gas products at 100° F. The vapor pressure may be used as a guide for controlling plant operations in production of a specification grade product.

Results are reported in pressure, psig at 100° F. (LPG Vapor Pressure Test, NGAA Test.)

Vapor Pressure of Gasoline Products (Reid Method). This method provides a simple, rapid means for obtaining vapor pressure of gasoline by a plant operator. Its purpose is a guide for controlling plant operation and producing a specification product.

Results are reported as pressure, psia., 100° F (Reid Method), ASTM Test D323-56).

API Gravity for Gasoline Products. This test determines the API gravity of gasoline and other petroleum products. Gravity can be used as a guide for controlling this phase of plant operations for producing a specification product.

Results are reported as gravity, °API. (API Gravity for Gasoline Products, ASTM D287-55).

Method of Distillation for Natural Gasoline. This method determines the boiling range of natural gasoline. This can be used by the plant operator as a guide for controlling plant operations for production of a specification grade product.

Results are reported as temperature, °F at volume intervals of 10 percent and at the initial and end points. Also reported is the recovery in percent. (Engler Distillation, NGAA Test.)

WATER TREATING

Water treating is needed in most plants to keep cooling water systems operating satisfactorily; in older plants, treatment may also be needed for steam boiler systems. Chemicals added to cooling water systems minimize production losses caused by microbiological growths, scale and corrosion.

Water is the most common and most nearly universal solvent known. This solvent power varies widely and it is this property which causes problems for plant opertors.

Microbiological Control. Open water systems are very susceptible to microbiological fouling because they are continually infected with airborne microorganisms. In most open water systems, we find all of the major forms of microscopic life. The ones which are most likely to cause trouble in a cooling system are algae, a green slimy material; bacteria of various forms which usually show up as a brown slime; and a fungus, which is usually impossible to see with the eye but is evidenced by an interior damage to cooling tower wood which makes it rot from the center out.

These microorganisms are controlled by adding poisonous substances to the water and it is the problem of the water treater to find a material that is inexpensive, that is poisonous to the microorganisms, and non-poisonous to the operating personnel working near the cooling tower.

These microorganisms cause difficulty in cooling water systems by stopping up pipes, by forming slimy coatings in heat exchangers and thus interfering with the transfer of heat, and by aiding in the corrosion process. A quaternary ammonium salt is frequently used to control the various microorganisms.

Scale Control. The ability of water to dissolve things in one place and lay them down in another gives rise to the problem of scale formation. The water dissolves part of the minerals in contacts under the ground before it comes out of the well. As this mineralized water is heated and concentrated in the cooling system, the water is unable to carry the amount of minerals that it picked up in its journey to the tower. The excess minerals are then deposited in the form of scale in the cooling equipment. The most prevalent scale-forming materials are silica, calcium sulfate and calcium carbonate. A typical water well analysis is shown in Table 4.

Silican scale formation is prevented by limiting the number of times that the water is concentrated by evaporation in the cooling tower. Acceptable concentrations are established by installing a blowdown or drain from the system.

Calcium carbonate scale is controlled by adding sulfuric acid to reduce the quantity of carbonate (or so called alkalinity) in the cooling water. An inhibitor (usually a phosphate) may be added to coat the scale-forming particles in such a manner that they are prevented from adhering and forming a continuous film of scale over the tube surface. Thus they can be washed out as separate particles in the blowdown.

Corrosion Control. Corrosion takes place in water systems due to the action of tiny electrical cells which are set up between various parts of the system. An inhibitor may be added to the water to reduce the effect of these little cells. The inhibitor (usually a chromate) has the property of making ordinary iron resist corrosion more like stainless steel in cooling water pipes. The major objective is to reduce the corrosion rate below 5 mils per year (1 MPY equals 0.001" average penetration per year). This corrosion rate has been found by most cooling system operators to be the point below which they cannot profitably pay for additional corrosion protection.

Water treating chemicals are quite expensive and the labor required to add this treatment properly is equally or more expensive. If the chemicals are controlled as recommended, the expense has proved to be well worth the money.

Normal Operation. Under normal conditions, the control of algae and other microorganisms in a cooling system depends upon the visual inspection of the cooling tower and such pieces of equipment as may be opened from time to time. When any slight growth of slime or algae is noted a dose of algacide should be added; and if none is noted, a calculated amount should be added at least once a month as a preventive measure.

The rate at which water is withdrawn from a cooling system through a drain or blowdown is controlled by the chloride test. As soon as the heat load is put on the cooling system, the chloride is measured. To lower the chloride, open the blowdown and drain more water from the system. The chloride reading may be raised by slowing the blowdown withdrawal rate.

The alkalinity is controlled with the rate of addition of sulfuric acid so that the alkalinity lies between 100 and 150 ppm as $CaCO_3$. When the alkalinity is above this range, additional sulfuric acid should be added, and when it falls below this range, sulfuric acid addition should be reduced or discontinued.

Operating Difficulties. With an internal water treatment system, the results, either good or bad, are not immediately apparent and no general operating difficulties will be experienced until some major damage has occurred. Usually protection from this hidden damage is attained by the periodic running of corrosion test specimens in the system to give assurance that the corrosion rate lies below 10 MPY and preferably in the range of 5 MPY. Scale control can be followed by periodically determining the over-all heat transfer coefficient of selected exchangers.

Safety. It pays to know the toxic properties of chemicals used in operations, as well as antidotes for accidents.

TABLE 3—Testing Guide for Plant Products

Product	Test	Procedure Reference
Propane	Vapor Pressure	ASTM D 1267-55
	Residue Test (Mercury Freeze)*	NGAA Technical Standards
	Volatile Sulfur	NGAA Technical Standards
	Corrosion (Copper Strip)	NGAA Technical Standards
	Dryness*	NGAA Technical Standards
	Weathering Test*	NGAA Technical Standards
	Acetylenes**	Light Hydrocarbon Analysis (Reinhold), L.H. No. 509
	Specific Gravity Test*	NGAA Technical Standards
	Weathering Test	Temperature Recorder Instrument
	Mercaptan Sulfur**	Light Hydrocarbon Analysis (Reinhold), L.H. No. 608
	Chlorides**	Light Hydrocarbon Analysis (Reinhold), L.H. No. 607
	Composition**	Fractional Distillation
	Composition	Chromatography
	Composition**	Mass Spectrometer
Butane-Propane Mixtures	Vapor Pressure	ASTM D 1267-55
	Weathering Test*	NGAA Technical Standards
	Volatile Sulfur	NGAA Technical Standards
	Corrosion (Copper Strip)	NGAA Technical Standards
	Specific Gravity*	NGAA Technical Standards
	Weathering Test	Temperature Recorder Instrument
	Mercaptan Sulfur**	Light Hydrocarbon Analysis (Reinhold), L.H. No. 608
	Composition*	Fractional Distillation
	Composition	Chromotography
	Composition**	Mass Spectrometer
Isobutane	Vapor Pressure	ASTM D 1267-55
	Weathering Test*	NGAA Technical Standards
	Volatile Sulfur	NGAA Technical Standards
	Corrosion (Copper Strip)	NGAA Technical Standards
	Specific Gravity*	NGAA Technical Standards
	Weathering Test	Temperature Recorder Instrument
	Mercaptan Sulfur**	Light Hydrocarbon Analysis (Reinhold), L.H. No. 608
	Composition**	Fractional Distillation
	Composition	Chromatography
	Composition**	Mass Spectrometer
Normal Butane	Vapor Pressure	ASTM D 1267-55
	Weathering Test*	NGAA Technical Standards
	Volatile Sulfur	NGAA Technical Standards
	Corrosion (Copper Strip)	NGAA Technical Standards
	Specific Gravity*	NGAA Technical Standards
	Weathering Test	Temperature Recorder Instrument
	Mercaptan Sulfur**	Light Hydrocarbon Analysis (Reinhold), L.H. No. 608
	Composition**	Fractional Distillation
	Composition	Chromatography
	Composition**	Mass Spectrometer
Refinery Butanes	Vapor Pressure	ASTM D 1267-55
	Corrosion (Copper Strip)	NGAA Technical Standards
	Volatile Sulfur	NGAA Technical Standards
	Weathering Test*	NGAA Technical Standards
	Specific Gravity*	NGAA Technical Standards
	Weathering Test	Temperature Recorder Instrument
	Mercaptan Sulfur**	Light Hydrocarbon Analysis (Reinhold), L.H. No. 608
	Chlorides**	Light Hydrocarbon Analysis (Reinhold), L.H. No. 607
	Acetylenes**	Light Hydrocarbon Analysis (Reinhold), L.H. No. 607
	Tetraethyl Lead**	UOP Laboratory Test Manual
	Composition**	Fractional Distillation
	Composition	Chromatography
	Composition**	Mass Spectrometer
Commercial Butane	Vapor Pressure	ASTM D 1267-55
	Corrosion (Copper Strip)	NGAA Technical Standards
	Volatile Sulfur	NGAA Technical Standards
	Weathering Test*	NGAA Technical Standards
	Specific Gravity*	NGAA Technical Standards
	Weathering Test	Temperature Recorder Instrument
	Mercaptan Sulfur**	Light Hydrocarbon Analysis (Reinhold), L.H. No. 608
	Chlorides**	Light Hydrocarbon Analysis (Reinhold), L.H. No. 607
	Tetraethyl Lead**	UOP Laboratory Test Manual
	Composition**	Fractional Distillation
	Composition	Chromatography
	Composition**	Mass Spectrometer
Isopentane	Reid Vapor Pressure at 100° F	ASTM D 323-56
	Corrosion (Copper Strip)	ASTM D 130-56
	Copper Dish Gum**	ASTM D 910-57 Sec. 9(j)
	Doctor Test*	NGAA Technical Standards
	Per Cent Unsaturates**	ASTM D 1268-55
	Color—Saybolt	ASTM D 156-53T
	API Gravity*	ASTM D 287-55
	Sulfur**	ASTM D 1266-57T
	Tetraethyl Lead**	UOP Laboratory Test Manual
	Composition**	Fractional Distillation
	Composition	Chromatography
	Composition**	Mass Spectrometer
Natural Gasoline	Reid Vapor Pressure at 100° F	ASTM D 323-56
	Corrosion (Copper Strip)	ASTM D 130-56
	API Gravity*	ASTM D 287-55
	Distillation	NGAA Technical Standards
	Doctor Test*	NGAA Technical Standards
	Color—Saybolt	ASTM D 156-53T
	Sulfur**	ASTM D 1266-57T
	Tetraethyl Lead**	UOP Laboratory Test Manual
	Arsenic**	UOP Laboratory Test Manual
	Octane Number (Motor)**	ASTM D 357-56
	Octane Number (Research)**	ASTM D 908-56

*Tests can be run in field by operating personnel.
**Usually run by outside laboratory.

For example, sulfuric acid in concentrated form is a hazardous chemical destructive to all forms of tissue. In any case of contact of personnel with sulfuric acid, immediate steps should be made to flush the burned area with water and the person taken to a doctor immediately. Should a doctor not be available, flushing with water followed by treatment as for a burn is usually recommended. Good safety practice requires the use of goggles and rubber gloves for all employes working with sulfuric acid. # #

Selected Reading for Further Study

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TABLE 4—A Typical Well Water Analysis
(Parts per Million)

Calcium Bicarbonate		29.1
Magnesium Bicarbonate		13.8
Sodium Bicarbonate		458.5
Sodium Sulfate		4.4
Sodium Chloride		108.8
Silica		23.1
Iron Oxide		0.3
Aluminum Oxide		2.7
Volatile and Organic Matter		21.0
Total Solids		661.7
Residue on Evaporation at 105° C	476	
½ Bicarbonate	183	
Estimated Total Solids	659	
Total Hardness as Calcium Carbonate		27
Phenolphthalein Alkalinity as Calcium Carbonate (to pH 8.3)		0
Methyl Orange Alkalinity as Calcium Carbonate		300
Free Carbon Dioxide		4
pH	8.10	

Ions:

Calcium	7.2	Bicarbonate	366.
Magnesium	2.3	Carbonate	0.
Sodium (Calc.)	170.1	Sulfate	3.
Iron (Fe)	0.2	Chloride	66.

Appearance: Faintly turbid

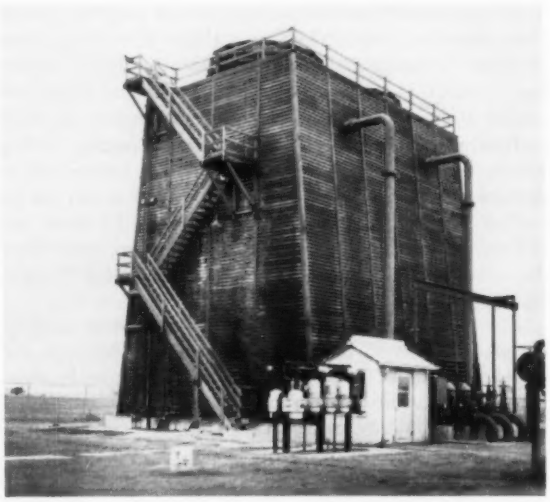

FIGURE 59—Cooling systems need to be watched for algae, scale and corrosion.

This Series in Book Form

Due to the enthusiastic response this series of articles has received, Gulf Publishing Co.'s Book Division is preparing the 12 parts of the "Operator's Handbook" for publication in hard back book form. Publication date will be shortly after the first of the year, but you may place your order now by circling E25 on the Reader Service Postcard.

Applied Hydrocarbon Thermodynamics

Part 22: Fugacities for Components of Vapor Mixtures

Wayne C. Edmister
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IT WAS PREVIOUSLY shown (Part 18) that the vapor-liquid phase equilibrium ratio depends upon the fugacities of each component in both liquid and vapor phases. Both of these fugacities can be computed from PVTC (pressure-volume-temperatue-composition) data by thermodynamic equations.

This fugacity computation can be made more easily and more accurately for components of the vapor phase than for the liquid. From calculated vapor fugacities and experimentally determined K-values the liquid fugacities may be found and correlated. This back-calculation of the fugacities for components of the liquid phase will be discussed later. At this point fugacity and activity coefficient of the components of the equilibrium vapor phase are of interest.

Fugacities are calculated from PVTC data, which may be correlated by graphical or analytical equation methods. Some of the equations of state are explicit in pressure, rather than volume. This requires a different thermodynamic relationship for the fugacity.

Alternate Equations for Fugacity Coefficients. The following expression was derived previously for the fugacity coefficient

$$\ln \frac{\bar{f}i}{Py_i} = -\frac{1}{RT}\int_O^P \left[\frac{RT}{P} - \bar{V}_i\right] dP \qquad (18.64)$$

which may also be written

$$\bar{f}_i = Py_i \exp\left\{\frac{1}{RT}\int_O^P \left[\bar{V}_i - \frac{RT}{P}\right] dP\right\} \qquad (21.1)$$

Another relationship is more convenient for use with pressure-explicit equations of state.

From Equation 18.12 for an isothermal path

$$\left(\frac{\partial A}{\partial V}\right)_T = -P$$

$$(\Delta A)_T = -\int PdV = +\int PV d\ln\rho \qquad (22.2)$$

From the definitions given in Part 18 for partial quantities, chemical potential and fugacity

$$(\Delta\bar{A})_T = \mu_i - \mu^o{}_i = \int\left(\frac{\partial(PV)}{\partial N_i}\right)_T d\ln\rho = RT \ln \frac{\bar{f}_i}{\bar{f}_i{}^o} \qquad (22.3)$$

Rearranging and adding $-RT \ln y_i$ to both sides gives

$$RT \ln \frac{\bar{f}_i}{y_i} = RT \ln \frac{\bar{f}_i{}^o}{y_i} + \int_{\rho o}^{\rho}\left(\frac{\partial(PV)}{\partial N_i}\right)_T d\ln\rho \qquad (22.4)$$

at low pressures (designated by * to distinguish from reference state using a zero superscript)

$$\bar{f}_i{}^* = y_i P = y_i \rho RT = \text{partial pressure}$$

combining while letting $P^o \rightarrow P^*$ and $\bar{f}_i{}^o \rightarrow \bar{f}^*$

$$RT \ln \frac{\bar{f}_i}{y_i} = RT \ln RT + RT \ln \rho^* + \int_{\rho^*}^{\rho}\left(\frac{\partial(PV)}{\partial N_i}\right)_T d\ln\rho \qquad (22.5)$$

but

$$RT \int_{\rho^*}^{\rho} d\ln\rho = RT \ln\rho - RT \ln\rho^* \qquad (22.6)$$

Combine Equations 22.5 and 22.6 and then let the lower limit ρ^* be zero

$$RT \ln \frac{\bar{f}_i}{y_i} = RT \ln \rho RT + \int_0^{\rho} \left[\left(\frac{\partial (PV)}{\partial N_i} \right)_{TVN_j} - RT \right] d \ln \rho \quad (22.7)$$

Subtracting ln P from both sides and rearranging gives

$$\ln \frac{f_i}{Py_i} = \frac{1}{RT} \int_0^{\rho} \left[\left(\frac{\partial (PV)}{\partial N_i} \right)_{TVN_j} - RT \right] d \ln \rho - \ln Z \quad (22.8)$$

Equation 22.8 may also be written in terms of V instead of ρ, as follows:

$$\ln \frac{\bar{f}_i}{Py_i} = \frac{1}{RT} \int_V^{\infty} \left[\left(\frac{\partial P}{\partial N_i} \right)_{TVN_j} - \frac{RT}{V} \right] dV - \ln Z \quad (22.9)$$

Equations 22.8 and 22.9 will be used in computing the vapor phase fugacity coefficients. The terms without subscripts apply to the entire mixture or the system. Thus, V, ρ and Z, as well as P and T apply to the mixture.

Virial Equations of State. PVT data may be represented by a power series of density or of pressure (reciprocal volume). These are called virial equations of state. The first is sometimes called the Leyden equation and the second the Berlin equation. These two equations are

$$\frac{PV}{RT} = Z = 1 + \frac{B}{V} + \frac{C}{V^2} + \dots \quad (22.10)$$

and

$$PV = RT + B'P + C'P^2 + \dots \quad (22.11)$$

where the virial coefficients B, C, etc., are functions of temperature and composition. B and B′ are called second virial coefficients. C and C′ are known as the third virial coefficients.

It is possible to show the relationships between the coefficients of one equation and those of the other by first multiplying both 22.10 through by RT/V and 22.11 by l/V, giving the following

$$P = RT/V + BRT/V^2 + CRT/V^3 \quad (22.12)$$

and

$$P = RT/V + B'P/V + C'P^2/V \quad (22.13)$$

Substitute 22.12 into 22.13, eliminating P on the right hand side,

$$P = \frac{RT}{V} + \frac{B'RT}{V} \left[\frac{1}{V} + \frac{B}{V^2} + \frac{C}{V^3} + \dots \right] + \frac{C'R^2T^2}{V} \left[\frac{1}{V} + \frac{B}{V^2} + \frac{C}{V^3} + \dots \right]^2 \quad (22.14)$$

Equations 22.12 and 22.14 are both series in l/V. Comparing like terms in these two equations gives the following relations between the coefficients of the Leyden and the Berlin equations.

From terms in l/V^2

$$B = B'$$

Since the second virial coefficient in both the Leyden and Berlin forms are equal, separate notations are not required for them.

From terms in l/V^3

$$(C - B^2)/(RT) = C'$$

The above is from Prausnitz,[15] who also gave the following relationship for the fourth virial coefficients

$$\frac{D - 3BC + 2B^3}{(RT)^2} = D'$$

From a theoretical point of view, the Leyden virial equation of state is superior to the Berlin form. From statistical mechanics considerations, it can be shown that compressibility factor is a function of reciprocal volume. More terms are needed in the Berlin form to get as good a representation as in the Leyden form with fewer terms. For example, if both equations are terminated after the second virial coefficient, i.e., B or B′, the Leyden equation hold up to one-half the critical density whereas the Berlin equation is good only to one-fourth the critical density.

The virial coefficients for mixtures are found from the corresponding values for the components and the mole fractions as follows:

$$B_M = \sum_i \sum_j y_i y_j B_{ij} \quad (22.15)$$

$$C_M = \sum_i \sum_j \sum_k y_i y_j y_k C_{ijk} \quad (22.16)$$

Equations 22.15 and 22.16 for second and third virial coefficients of mixtures apply for any number of components, two and higher. These relationships are based upon assumed models of molecular interaction.

For B, the second virial coefficient, the assumption is made that each component collide with itself and with each other component. In general

$$B_M = \sum_i (y_1 y_1 B_{11} + y_1 y_2 B_{12} + y_1 y_3 B_{13} + \dots + y_1 y_j B_{1j}) \quad (22.17)$$

For a binary

$$B_M = y_1^2 B_{11} + 2y_1 y_2 B_{12} + y_2^2 B_{22} \quad (22.18)$$

For a ternary

$$B_M = y_1^2 B_{11} + y_2^2 B_{22} + y_3^2 B_{33} + 2y_1 y_2 B_{12} + 2y_1 y_3 B_{13} + 2y_2 y_3 B_{23} \quad (22.19)$$

In Equations 22.18 and 22.19, it is asumed that

$$B_{ij} = B_{ji}$$

The two number subscripts of these equations identify the intermolecular action.

The equations for C_M, the third virial coefficient of a mixture is based on three body collisions where molecules of each component are involved in all possible collisions, i.e. (a) with two of its own kind, (b) one of its own kind and each other molecule present, and (c) with all possible combinations of the other molecules present in the mixture. Another basis is the assumption that $C_{ijk} = C_{kji}$, i.e. the coefficient is independent of the order.

For a binary mixture

$$C_M = y_1^3 C_{111} + y_2^3 C_{222} + 3y_1^2 y_2 C_{112} + 3y_2^2 y_1 C_{221} \quad (22.21)$$

Three kinds of virial coefficients are involved with mixtures: (a) those for the pure components, identified as B_{11}, B_{22}, B_{33}, etc. and C_{111}, C_{222}, C_{333}, etc.; (b) the interaction coefficients, identified as B_{12}, B_{13}, B_{23}, etc. and C_{112}, C_{113}, C_{122}, C_{123}, C_{133}, etc.; and (c) the mixture coefficients, identified as B_M and C_M.

Pitzer et al[6,7], in their improved correlation of compressibility factors, derived a generalized relationship for the second virial coefficient, which is

$$\frac{B P_C}{R T_C} = 0.1445 + 0.073\omega - \left(\frac{0.33 - 0.46\omega}{T_r}\right) - \left(\frac{0.1385 + 0.50\omega}{T_r^2}\right) - \left(\frac{0.0121 + 0.097\omega}{T_r^3}\right) - \left(\frac{0.0073\omega}{T_r^8}\right) \quad (22.23)$$

The "reduced" second virial coefficient BP_C/RT_C is a function of reduced temperature, T_r, and acentric factor, ω.

Fugacity Coefficient via Virial Equation of State. An expression for the fugacity coefficient, $\phi_i = \bar{f}_i/Py_i$, in terms of these virial coefficients and cross coefficients is obtained from Equations 22.9 and 22.10 for a mixture of N moles, where $N = \Sigma n = n_i + n_j + \ldots$

In Part 18, the moles of each component were designated as N_2, N_1 etc. This notation is awkward in the following derivatives and was changed for convenience and clarity.

Equation 22.10 may be rewritten

$$P = \frac{\Sigma n}{V_N} RT + \frac{(\Sigma n)^2}{V_N^2} RTB_m + \frac{(\Sigma n)^3}{V_N^3} RTC_m + \ldots \quad (22.24)$$

where: V_N = volume of N moles of mixture.

Differentiating Equation 22.24 with respect to n_i the moles of component i neglecting the higher order terms:

$$\left(\frac{\partial P}{\partial n_i}\right)_{TVnj} = \frac{RT}{V_N}\left(\frac{\partial \Sigma n}{\partial n_i}\right)_{TVnj} + \frac{RT}{V_N^2}\left[\frac{\partial}{\partial n_i}\left\{(\Sigma n)^2 B_m\right\}\right]_{TVnj} + \frac{RT}{V_N^3}\left[\frac{\partial}{\partial n_i}\left\{(\Sigma n)^3 C_m\right\}\right]_{TVnj} \quad (22.25)$$

From the definitions of n_i and Σn it follows that $(\partial \Sigma n/\partial n_i) = TVN_j = 1.0$

Equations 22.15 and 22.16 are equivalent to

$$B_m = \sum_i \sum_j \frac{n_i n_j}{(\Sigma n)^2} B_{ij} \quad (22.26)$$

and

$$C_m = \sum_i \sum_j \sum_k \frac{n_i n_j n_k}{(\Sigma n)^3} C_{ijk} \quad (22.27)$$

From these the following terms of Equation 22.25 are found as follows:

$$\left(\frac{\partial B_m}{\partial n_i}\right)_{TVn_j} = 2 \sum_i \sum_j \left[\frac{n_j}{(\Sigma n)^2} - \frac{n_i n_j}{(\Sigma n)^3}\right] B_{ij} \quad (22.28)$$

and

$$\left(\frac{C_m}{\partial n_i}\right)_{TVn_j} = 3 \sum_i \sum_j \sum_k \left[\frac{n_i n_j}{(\Sigma n)^3} - \frac{n_i n_j n_k}{(\Sigma n)^4}\right] C_{ijk} \quad (22.29)$$

Evaluating Equation 22.25 in terms of these virial coefficients and their first composition derivative lead to the following expression

$$\left(\frac{\partial P}{\partial n_i}\right)_{TVn_j} = \frac{RT}{V_N} + \frac{RT}{V_N^2}\left[2 \sum_j n_j B_{ij}\right] + \frac{RT}{V_N^3}\left[3 \sum_j \sum_k n_j n_k C_{ijk}\right] \quad (22.30)$$

The terms in the brackets mean that the indicated summations are made for component "i" colliding with itself and each of the other components present. This will be illustrated later for a binary mixture.

Substituting Equation 22.30 into 22.9, integrating, consolidating terms and returning to mole fractions via definition $y_i = n_i/\Sigma n$

$$\ln \phi_i = \frac{2}{V} \sum_j^n y_j B_{ij} + \frac{3}{2V^2} \sum_j^n \sum_k^n y_j y_k C_{ijk} - \ln Z \quad (22.31)$$

Equation 22.31 was recently discussed by Prausnitz[11]. For the binary mixture case

$$\ln \phi_1 = \frac{2}{V}\left[y_1 B_{11} + y_2 B_{12}\right] + \frac{3}{2V^2}\left[y_1^3 C_{111} + 3y_1^2 y_2 C_{112} + 3y_2^2 y_1 C_{221}\right] - \ln Z \quad (22.32)$$

Equations 22.31 and 22.32 give the fugacity coefficient for a component of a mixture in terms that component's virial coefficients and its interaction coefficients with the other components in the mixture.

A similar fugacity coefficient relationship can be found from the Berlin Virial equation of state, i.e. Equation 22.11, and the partial volume relationship for fugacity coefficient, i.e. Equation 18.64. By definition: $\bar{V}_i = (\partial V_N/\partial n_i)_{PTn_j}$.

Rewriting Equation 22.11 for $\Sigma n = N$ moles, for which the volume is V_N, and leaving the prime off B but designing mixture virial coefficient values by subscript m.

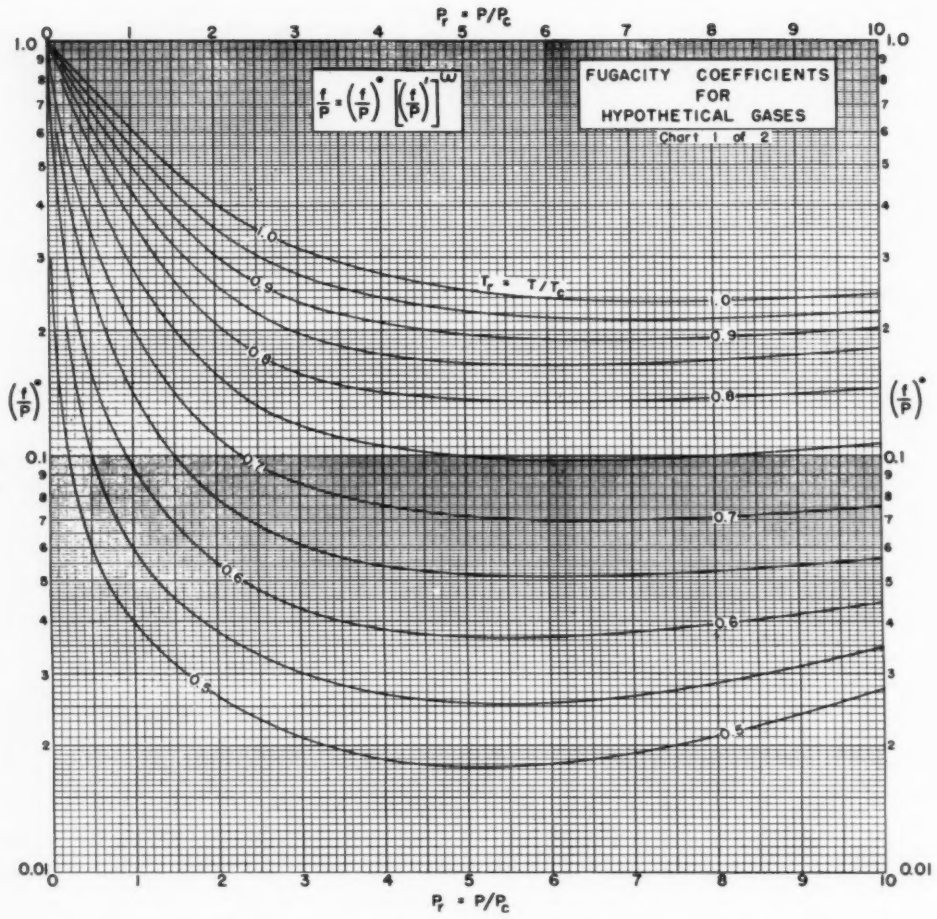

FIGURE 22.1—Fugacity coefficients for hypothetical gases (Chart 1 of 2).

$$V_N = \frac{(\Sigma n)\,RT}{P} + (\Sigma n)B_m + (\Sigma n)C_m'P \qquad (22.33)$$

Differentiating

$$\left(\frac{\partial V_N}{\partial n_i}\right)_{PTn_j} = \frac{RT}{P} + B_m + (\Sigma n)\,(\partial B_m/\partial n_i)_{PTn_i} + C'_m P + (\Sigma n)\,P\,(\partial C_m'/\partial n_i)_{PTn_i} \qquad (22.34)$$

Assuming that Equation 22.29 gives the value of $(\partial C_m'/\partial n_i)$ as well as $(\partial C_m/\partial n_i)$ and using Equation 22.28 for $(\partial B_m/\partial n_i)$ in Equation 22.34 leads to the following for $\overline{V}_i$

$$(\Sigma V_N/\partial n_i)_{PTn_j} = RT/P + \sum_i \sum_j \left[\frac{2n_j}{(\Sigma n)} - \frac{n_i n_j}{(\Sigma n)^2}\right] B_{ij} + P \sum_i \sum_j \sum_k \left[\frac{3n_i n_j}{(\Sigma n)^2} - \frac{2n_i n_j n_k}{(\Sigma n)^3}\right] C_{ijk} \qquad (22.35)$$

Substituting Equation 22.35 into Equation 18.64 and rearranging leads to the following expression for ϕ_i in the Berlin equation coefficients

$$\ln \phi_i = (1 - Z) + \frac{2P}{RT} \sum_j^n y_j B_{ij} + \frac{3P^2}{2RT} \sum_j^n \sum_k^n y_j y_k C'_{ijk} \qquad (22.36)$$

Similarities and differences between Equations 22.31 and 22.36 should be noted.

Evaluation of Virial Cross Coefficients. Theoretically these interaction coefficients, B_{ij} and C_{ijk}, can be evaluated from PVT data for each component and for mixtures of these components. This requires very precise PVT data and involves careful calculations, especially for the third virial and its cross coefficients.

In addition to having PVT data for the pure components and obtaining B and C for the single component system, data on at mixtures of at least three different compositions are required for deriving the cross coefficients.

In some recent work Prausnitz[9,11] obtained second

virial cross coefficient, B_{12} values from the equilibrium vapor of binary mixtures by applying Equation 22.32, without the third virial term to observed vapor-liquid equilibria data. In other words, the value of B_{12} was back calculated for a binary, starting with the observed x-y data and the liquid phase fugacities plus the value of B_{11} for the pure component.

This analysis of observed vapor-liquid equilibria data is of primary interest for the solvent, small amounts of which will be dissolved in the equilibrium vapor. The solubility of heavy components in the gas phase was studied by Prausnitz[12] by obtaining compositions of equilibrium gas and then computing the B_{12}. This was done without knowing the compositions of the liquid phase, which was largely solvent. For this case the liquid activity coefficient of the solvent could be assumed to be unity and its fugacity in the liquid found by applying the Lewis and Randall rule.

From the fact that the fugacity of the solvent in the vapor phase is equal to its value in the equilibrium liquid, the value of $\bar{f}_1/Py_1$ was found. Then the value of B_{12} was found, using the values of B_{11}, y_1, and y_2.

When the liquid mole fraction of the solvent is much less than unity, the values of x, as well as y, are required. The general relationship for back calculating the vapor fugacity coefficient is

$$\phi_i = \frac{f^L/P}{y_i/x_i}\,\gamma_i^L \qquad (22.37)$$

This or other variations of the fugacity relationship for vapor-liquid equilibria are used depending upon the composition and conditions.

The second virial cross coefficients thus determined in the above referenced work by Prausnitz and his coworkers were correlated as a function of average acentric factor, average critical volume, average critical temperature, and system temperature, as follows:

$$\frac{B_{ij}}{Vc_{ij}} = \Theta_B\left(\frac{T}{Tc_{ij}}\ ,\ \omega_{ij}\right) \qquad (22.38)$$

where: V_{cij}, T_{cij}, and ω_{ij} are average or pseudo critical values for the mixture. Different combinations of the component properties were tried.

In another work Prausnitz and Benson[13] correlated the second interaction coefficient, B_{ij}, with collision diameters. This is beyond the scope of this series.

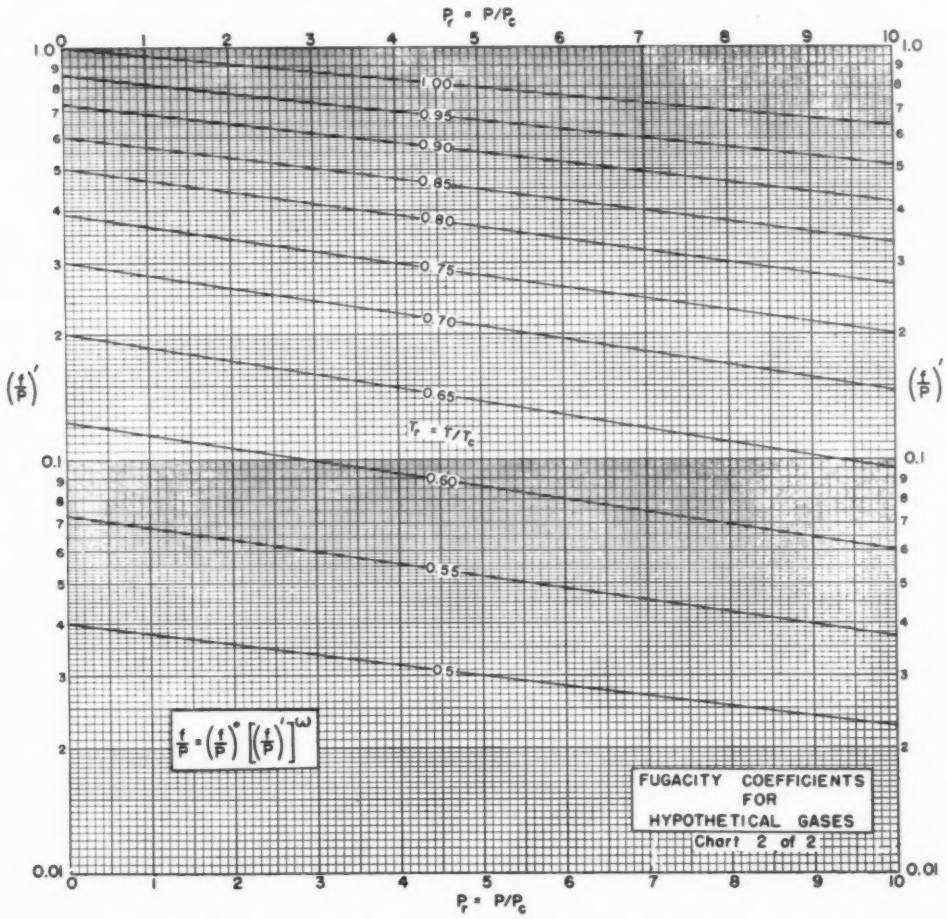

FIGURE 22.2—Fugacity coefficients for hypothetical gases (Chart 2 of 2).

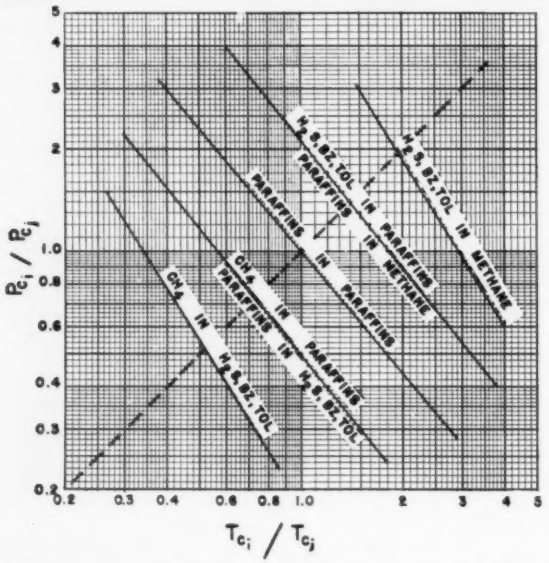

FIGURE 22.3—Critical ratio (solute/solvent) relationship for mixtures.

Hypothetical Vapor State. In analyzing vapor-liquid equilibria data it is worthwhile to know the deviation from ideal mixtures, i.e. from the Lewis and Randall fugacity rule. This deviation is shown by the values of the activity coefficient, which is the ratio of the fugacity coefficient of a component in a mixture to the value in a pure reference state at the same temperature and pressure. In other words, the activity coefficient of a component shows the activity of that component relative to its activity in the standard reference state.

The standard state of a heavy component dissolved in light gaseous components is the pure solute (heavy component) as a gas at the temperature of the vapor phase. If the standard state is taken at the system pressure and if this pressure exceeds the vapor pressure of the pure component so that this heavy component cannot exist as a pure gas, the standard state is hypothetical.

On an f/P chart, such as the one given previously as Figure 18.1, the hypothetical gas region is the $T_r < 1.0$ area. The $T_r < 1.0$ isotherms on Figure 18.1 were obtained by extrapolations using some observed vapor-liquid equilibria data. This f/P was used in developing the well known MIT K values. Figure 18.1 is too much of an approximation, however, as the f/P is not simple function of T_r and P_r.

Prausnitz[14] recently derived some fugacity coefficients for hypothetical gases in integrating the equation

$$\ln \frac{f}{P} = \int_O^P (Z - 1) \frac{dP}{P} \qquad (22.39)$$

with volumetric data for actual gases and then generalizing the resulting f/P values.

In making these integrations from the normally gaseous state through the two phase (gas-liquid) region and into the normally liquid retion, Prausnitz drew in smooth and continuous isotherms to replace the pure component isotherms in the two phase region. These isotherms were drawn in such a way as to join the pure component isotherm at about twice the critical pressure. For pressures greater than the vapor pressure these new isotherms established hypothetical gas, which Prausnitz recommends as a reference state for computing vapor activity coefficients.

Integrations of these isotherms for different gases gave values of f/P from which three charts of f/P vs P_r and T_r were drawn, one for $\omega = 0$, one for $\omega = 0.2$ and another for $\omega = 0.4$. Figure 22.1 is a redrawn version of Prausnitz's plot for $\omega = 0$. The plots for $\omega = 0.2$ and $\omega = 0.4$ were reworked into the same form Pitzer et al[7] used in correlating f/P values, i.e.

$$f/P = f/P)^\circ \left[(f/P)' \right]^\omega \qquad (18.76)$$

Figure 22.2 gives the $(f/P)'$ values vs P_r and T_r.

As shown on Figures 22.1 and 22.2 the values of f/P are found by finding $(f/P)^\circ$ and $(f/P)'$ and then combining these by Equation 18.76. Both Figures 22.1 and 22.2 are extrapolations to $T_r = 0.5$. Also Figure 22.2 represents some smoothing of Prausnitz's values. This seems justified because the important thing is to have consistency in the hypothetical f/P values.

Critical Ratios as Composition Parameter. The critical constants of the solute and solvent of a mixture have possibilities as a composition parameter. This is shown by plotting the ratio P_{ci}/P_{cj} vs T_{ci}/T_{cj} for seven types of mixtures on Figure 22.3. Subscript "i" refers to solute, while subscript "j" refers to solvent.

These seven types of mixtures are indicated in the following tabulation, where the combinations are listed in the left to right order they appear on Figure 22.3.

45° Intercept	Solute	Solvent
0.52	CH_4	H_2S, Benzene, Toluene
0.73	Paraffins	H_2S, Benzene, Toluene
0.73	CH_4	Paraffins
1.0	Paraffins	Paraffins
1.40	Paraffins	CH_4
1.40	H_2S, Benzene, Toluene	Paraffins
1.94	H_2S, Benzene, Toluene	CH_4

The values of the ratios T_{ci}/T_{cj}, and P_{ci}/P_{cj} for plotting Figure 22.3 were computed for binary systems. The arrangement of the lines on Figure 22.3 indicates the departure from the ideal paraffin-in-paraffin case.

Using both critical ratios to define the departure from ideality is more complex than seems really necessary for the vapor phase. The departure from the paraffin-in-paraffin case can be measured along the dashed 45° line where the two critical ratios are equal. These intercepts are given in the above tabulation.

It is of interest to note that the intercepts bear a reciprocal relaionship to each other, i.e. 1.94 to 0.52 and 1.40 to 0.73. These intercepts appear to have possibilities worthy of further investigation.

For multicomponent mixtures these critical ratios would be computed by regarding each component as the solute and everything else as the solvent, taking average or pseudo criticals for the mixed solvent.

LITERATURE CITED

Literature references for Parts 22 and 23 are at the end of Part 23.

TO BE CONTINUED

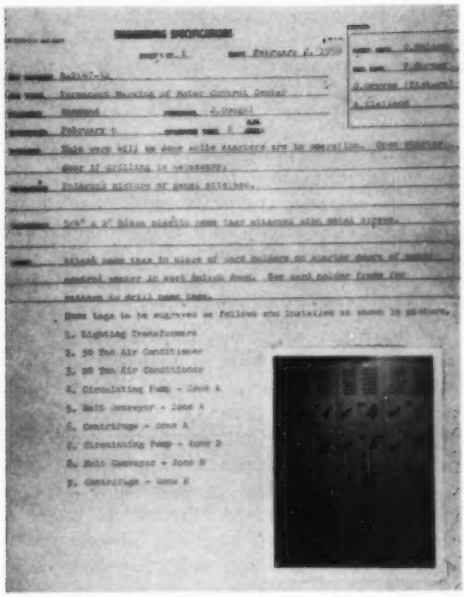

FIGURE 1—Marking a photo and attaching it to a form gives the craftsman better information about the job he is to do.

Photographs Speed Field Repair Information

The usual problem is not doing the work, it's finding it

C. B. Hammond, Monsanto Chemical Company
Springfield, Mass.

THE USE of photographs to replace written instructions and drawings is particularly well suited to plant maintenance applications. One reason is that because of the growth of maintenance departments, communication problems have grown. It is no longer practical to rely on verbal instructions and crude sketches to relay information to the field crew; and it is difficult to increase the number of drafting and clerical personnel. Another benefit is that the three dimensional effect of a photograph, coupled with its clarity of detail, makes the work recognizable much quicker than a drawing to a person who is unfamiliar with engineering drawings.

Photographing Minor Repair Work. The foreman will find that photographs are helpful in defining the scope of the work and in choosing the best craftsman for each assignment. He can also group similar jobs together and send a crew out to repair a number of like jobs in a given area. This is particularly suited to such jobs as valve repair, piping replacement and minor building repair. A frequent problem is not doing the work, it's finding it.

The pictures taken are marked to show the location, job to be done and the crafts involved. These pictures may then be clipped to a repair order or job specification form as shown in Figure 1 and turned over to the scheduler or area foreman.[1]

A good technique is to orient the necessary repair with an easily recognized landmark. This can be a major piece of equipment or a building feature. In extreme cases it is helpful to give a geographical reference such as the northwest corner of Building 21 or an outline sketch of the area with the picture locations shown by an "X," perhaps with a distance reference to some nearby feature. The foreman will find that his effort can be increased by not having to spend as much time guiding craftsmen to the job site. He also does not have to refer back to the engineer as often for further identification.

Another advantage is in assigning work to shift people who may not have as close supervisory coverage as the day crew. In this case the craftsman has a clearer assignment, which results in a better probability that the work will be done. This can improve the utilization of shift and emergency crews by allowing more scheduling of routine maintenance.

The craftsman is usually the most receptive to this technique. His efficiency is improved when he is less dependent on his supervision for information after the job has been assigned. As a rule craft people make a greater effort to understand a photograph than they do drawings or written instruction.

FIGURE 2—Photos of special tools used on a job gets the idea over quickly.

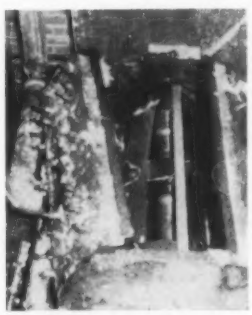

FIGURE 3—Photos of equipment failures "as found" helps in redesign to prevent recurrences.

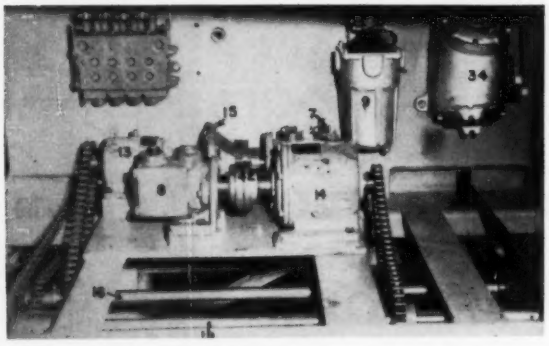

FIGURE 4—Numbered photos of equipment components set maintenance requirements.

By studying the picture prior to leaving the shop, the craftsmen can determine what tools are required and occasionally the parts that may be needed to effect the repair. At Monsanto, the building repair crew is using these pictures to determine the amount of cement and brick to do masonary repairs and the amount of plaster for wall and ceiling work. These materials are prepared in the shop and taken to the job before the mason has seen the work.

Major Repair Work. Photographs can be used to illustrate and record many phases of the major repair work.

In the case of emergency work, the engineer will be able to save time by using prints to show dismantling procedures and as a guide for later reassembly. These prints are also helpful to determine the number and sequence of crafts to be scheduled.

Handling of repetitive jobs can be improved by maintaining a file of pictures showing special aspects of the work. A series of crayon-marked prints showing the repair in sequence will make it unnecessary to have the same craft people doing the work each time. Pictures of special tools, rigging and scaffolding help to reduce the amount of supervision required and save time in preparing to do the work (Figure 2).

Actual photographs of the failure as it was found will help the engineer redesign or revise the equipment to prevent recurrence. These pictures are also of value to the equipment manufacturer when he is called in to consult on repair problems (Figure 3).

A major repair of process equipment usually presents an opportunity to inspect machines and facilities that are not accessible during normal operations. Pictures showing the effect of wear and corrosion can be used to illustrate and document justifications for future repairs or replacements.

A series of pictures showing progressive failures such as blisters on tank linings and corrosion of vessel interiors are helpful in determining the potential life of the equipment and in selecting a more suitable replacement.

Sending repair work outside the plant often involves frequent trips for engineers and supervision to check the status and quality of the work. The frequency of these trips and the number of people involved can be reduced by sending one man with a camera to record the work for later consideration by interested groups. These pictures are also useful in establishing the capabilities of the outside shop for future work.

New Installations. Photographs can be used effectively in many stages of a new installation. They are used initially by the engineer and draftsman as a guide in preparing drawings for equipment location and building modifications. On small projects, relocating existing equipment or duplicating existing installations, pictures can be used exclusively to advantage.

During the course of a new installation, photographs are useful to document revisions or deviations from the drawings. These changes can be incorporated into drawing revisions at a later time. Pictures of equipment showing the as-installed condition can be used as a reference for establishing maintenance requirements. These pictures are marked to show such information as lubrication requirements, adjustment of linkages and frequency of inspections (Figure 4). These pictures are also useful to the operating departments to illustrate operating procedures and safety precautions.

These same pictures can be used to improve engineering reports after the completion of a project and in local newspapers or employe publications to publicize plant improvements.[2]

Transparencies. One minute positive transparencies have many practical applications in plant maintenance work. These slides are made in the camera and can be projected at once for classroom instruction, on-job training and safety presentations. The real advantage of the transparenices is that it can be reproduced by diazo copying techniques at a cost of less than one cent per copy. There is a slight loss in detail and tonal range with standard diazo paper. This can be improved by using a cross line contact screen with 120 rulings to the inch and by using the more sensitive diazo materials such as sepia paper or film.

Originally presented to The American Society of Mechanical Engineers Petroleum Mechanical Engineering Conference, New Orleans, Sept. 19, 1960.

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About the Author

Hammond

Clayton B. Hammond is superintendent of the Engineering Section in the Plant Engineering Department at Monsanto Chemical Company's Plastic Division Plant in Springfield, Mass. In this position he supervises the engineering effort necessary to maintain and improve the equipment and facilities used in the manufacture of plastic materials. Mr. Hammond received a B.S. degree in mechanical engineering from Norwich University in 1951 after which he joined Monsanto as an area engineer. Since that time he has held the title of senior engineer before assuming his present position.

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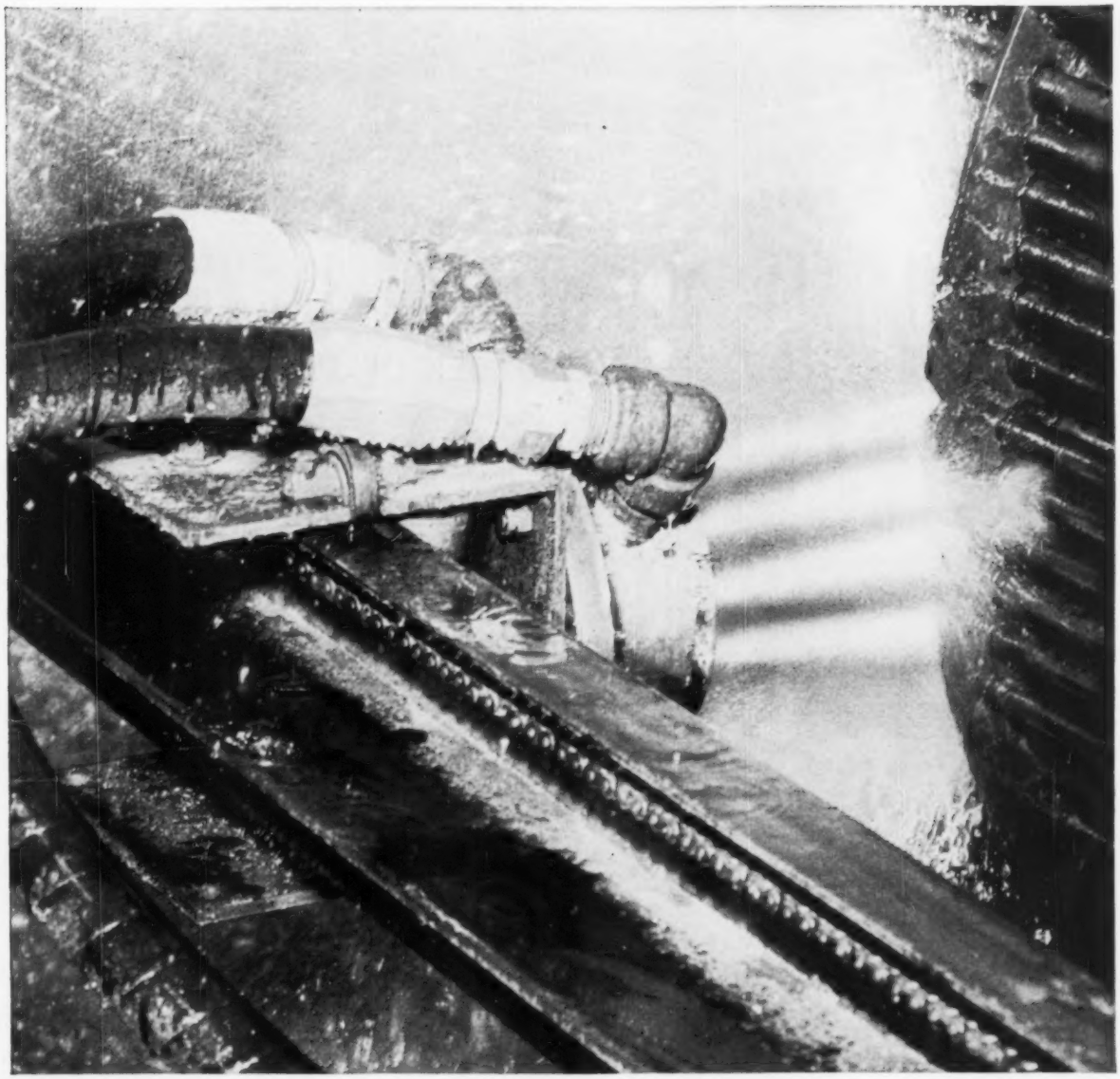

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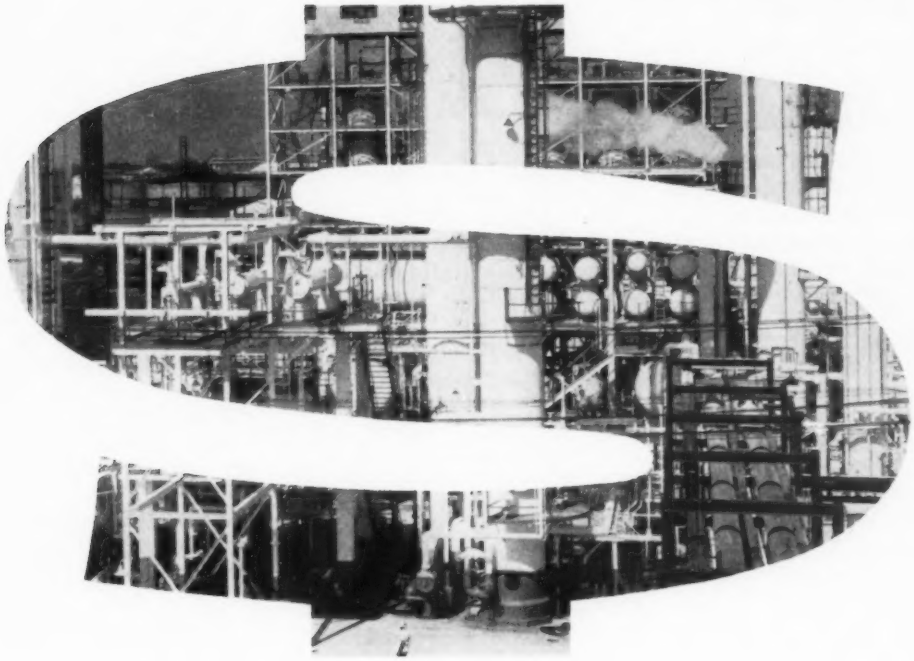

How to Get Investment Efficiency

Here are some of the causes of low investment efficiency, plus six principles you can apply to any project to make sure you are getting your money's worth

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HOW IS YOUR investment efficiency for capital projects? If you are the average refinery, we'll bet it's not as good as you would like it to be. You are probably in the same boat as many refineries—after a new capital project is installed, you find it's really not as good as had been predicted.

Why is this so? There may be a variety of reasons but an investigation would probably reveal that almost all the reasons can be classified under the six separate categories of fundamental principles discussed in this article. You can improve your investment efficiency if you put these principles into practice in your organization.

Measuring Efficiency. The only real way to gage the efficiency of a capital investment in a refinery is to see if it enables a real increase in barrels per day refined and sold. This could be expressed as maximum dollar income for minimum dollar expenditure. One measure of this would be an index of barrels per day refined throughput per unit of plant investment.

If this statistic showed a declining trend it would indicate that either of two things were happening. First, it could be an effect resulting from installation of too much intricate processing equipment—sometimes called in the practical sense, "lace." Or, second, there would be the effect of pre-investment due to installing equipment and spending capital money ahead of the real need to do so. This latter situation generally results from the protective desire for flexibility in processing equipment, when, in fact, this flexibility may not really be needed.

The Causes. The causes of low investment efficiency are the result of a number of things. Some of these are:

1. Slipping too many flexibility items, not really essential to operations, into new capital projects.
2. No support from management of sound but radical new ideas to reduce investment needs.
3. Too little encouragement given

to the advantageous alternative of engineering studies to reduce investment in offsites.

4. Paying scant attention to the possibilities of repairing equipment on expense in lieu of installing new replacements.
5. Putting too little emphasis on utilizing more modern, low cost construction possibilities.
6. Reluctance to purchase available surplus equipment instead of new equipment.
7. Developing too far those new projects that show a low profit margin.
8. Too much emphasis on a policy to cover 100 percent of the business for a particular product or products when there is actually little economic basis.
9. De-emphasizing the old practice of low cost "bottleneck removal" of existing facilities.
10. Tendency of technical organizations to concentrate too much manpower on new glamorous approaches and processes—or too much regurgitation of old data and old processes.

There are undoubtedly other reasons which we could list, but they would be beside the point. The problem is more toward one of looking back for some fundamental principles we can relate to all of the possible reasons for experiencing a low investment efficiency.

Fundamental Principles. The fundamental principles that we feel are important for improving investment efficiency are:

1. Keep trying to increase thruput
2. Don't be "too safe"—safety and fire protection
3. Look at the "over-all" solution to integrated problems
4. Don't exceed the economic minimum of spare equipment
5. Watch those "predictions" of the future
6. Don't foresake "bottleneck removal."

Everyone will usually agree, after seeing the list, that the fundamental principles of improving investment efficiency are well known and will appear obvious and simple as they are discussed. It's sort of like the armchair quarterback session after the football game. But our problem is actually the next football game. We may never really seem to concentrate on the application of these fundamental principles to our next budget although we do talk about them.

Organizations frequently fail to apply these principles because of psychological or personal reasons—or perhaps because it does not occur to them that a paricularly good project should be given a real healthy questioning. Frequently, they proceed without sufficient data even though these data are available—but require too much engineering effort to assemble and properly evaluate. So let's go on and discuss in more detail each of the principles we listed.

1. Keep Trying to Increase Thruput. We should keep trying to find ways and means of increasing processing or handling more volume on existing equipment without expenditure. We can apply this principle to major processing equipment, utilities, offsite lines, and tankage. All this type of equipment has two kinds of capacity:

A. A real scientific or mechanical capacity which can be achieved through close technical, mechanical, and operational cooperation.

B. A psychological capacity which the organization actually imposes upon the equipment. This capacity may be slightly below, or even considerably below, the real mechanical capacity.

The mechanical capacity of a particular installation is frequently not easily achieved. In fact, the entire economic life may slip by without an organization ever realizing that they ran the equipment at psychological capacity rather than at mechanical or real capacity—whichever is higher.

You will realize mechanical capacity only after tedious, extremely detailed, difficult work, and intensive training of mechanical, technical, and operational personnel. Now, the first step is to develop a team approach in which the organization takes real pride in solving problems with ingenuity rather than by adding hundreds of thousands of dollars investment to the plant.

The philosophy, "We must continue to develop large capital additions and changes to our plant otherwise we aren't doing our job," is a trap which any organization can fall into. This is particularly true after an extended boom or expansion period.

2. Don't Be Too Safe. The second area in investment efficiency which we wish to examine is in safety and fire protection. This phase of the business is subject to overemphasis as well as underemphasis. Cutting out projects with a title of "safety" can really become taboo, particularly after they have passed through several levels of supervision without getting a real shakedown analysis at any point. It takes real courage to turn down a safety and fire protection project in the face of a heavy emotional appeal. Mind you, we say emotional appeal—not logical analysis.

There are a number of shortcomings in the development of these kinds of capital expenditures. One is the feeling that if a safety survey doesn't result in recommendations for capital additions or changes, then someone hasn't done a thorough job. Quite often it is considered necessary to cover yourself by recommending safety facilities to cover extremely remote possibilities. The feeling is that things just aren't as safe as possible, therefore, something must be done.

So far, so good. But the next step in the "logic" process leads many to the conclusion that capital money should be expended to improve the situation. And this is not only possibly false, it is actually dangerous. It is dangerous in that, after building these fine safety and fire protection facilities, an organization can fall into the "Maginot Line" complex.

Then too, there is a tendency, when too many safety items are around, for the maintenance to slide or for the operational personnel to forget. In such a case, if the need arises, the equipment won't function or is not used properly. So it might as well not have been there in the first place.

A second shortcoming of investments in this category can easily occur along the following lines.

Units A and B have been built and operating for years, fully and adequately protected from a safety and fire protection and viewpoint. Unit C is now built during profitable booming years. The designer adds a few extra luxuries to the unit because they can be installed for incremental cost. Or perhaps the "extra" might be worthwhile because of some unique situation.

After a short time, the old units A and B are given a review for safety in the light of the new unit C. The conclusion of the reviewing committee is that the old units must be sub-standard and the new unit becomes the standard. So capital funds are now required for the old units. Of course, the real truth is that units A and B are fully adequate and may be above standard, while the new unit should be classified as super-standard. Frequently, no level of management is offered such a viewpoint.

The foregoing is definitely not an argument against safety and fire protection. The company's personnel and equipment certainly must have good protection. The point is that well-trained personnel and good maintenance are the best possible protection, and these factors can be taken into account in order to avoid unnecessary and doubtful capital expenditures.

3. Look For Over-all Solutions. A third major principle by which investment efficiency can be increased is by solving operating equipment and safety problems on an integrated basis. That is, look at a single over-all complete solution. Frequently, a single problem receives two, three or even four solutions, while a single solution would suffice.

For example, let us suppose that a leaking exchanger introduces an unmanageable quantity of hydrocarbons into the separator. The equipment inspection or mechanical personnel promptly replace the guilty tube bundle with a new metal that won't fail and, to make absolutely sure of a 20-year life, cathodic protection is also installed. Meanwhile, process and operational people conclude that additional separator capacity should be installed in case the situation ever occurs again. Pencils are "sharpened" and big payouts are shown.

Now, we have spent money on three solutions. If there has been a recent fire and everyone is extra safety-conscious at this point, it is possible to get a fourth solution by installing additional monitor nozzles to cover such future possible big spills or leaks.

4. Economic Minimum of Spare Equipment. In order to maintain investment efficiency, spare equipment must be held at a minimum, consistent with sound economics and good safety practices. Here again it is possible to develop an overly conservative and uneconomic attitude towards what is required in the way of spare capacity. Undue concern can reach such a pitch that the organization feels that spare capacity should be such that 100 percent of the time a spare replacement is standing by ready to be instantaneously placed in service.

Let's consider what this attitude will do for our capital plant. Two pieces of operational equipment are required to keep a plant running at full capacity. A third piece of equipment is standing by as spare. There is a failure and the spare is placed in service. Now what is the situation? The plant has no standby spare since one piece is down for extended repairs. It is easily possible for this spot emergency to lead to investing in still another spare—particularly if there is a series of unusual failures and one of the three pieces seems to be in a continuous overhaul.

It is easy to forget many years of trouble-free operation and remember the single, short "emergency." What is the real situation in the case of our equipment failure? It is as follows:

A. The spare which has just been placed in operation is mechanically brand new, or should be, and should run for a year or so, trouble-free.

B. Before another failure can occur the odds are overwhelmingly in favor of repairs being completed.

C. Even if additional failures do occur, the plant can still run at reduced capacity. This gives us a chance to use that tankage inventory which was justified partly on the basis of just such an emergency.

D. Furtherfore, there is a bit of surplus processing capacity that can be used to build that inventory back up after these unlikely simultaneous failures have happened. Again, that surplus capacity was justified for just such a situation.

So, make every effort to use that inventory and surplus capacity to avoid investing in more spares. Recognize infrequent tight situations as normal, expected operating conditions rather than as opportunities to obtain capital to absolutely assure "full throttle" operation at all times.

5. Watch Those Predictions. We should make sure that the project is being installed on the basis of the best available predictions rather than on an historical trend or present situation in which it is known there will be a downward movement. Non-representative peaks, unlikely situations, or infrequent emergencies can rarely be used to justify investment. If these factors enter into the justification, then it must be made clear as to the extent they do enter into the project.

Unlikely situations and non-representative peaks are often presented to management as normal situations. This is not dishonest—the fact is that the trouble spots are so vividly recalled that it is easy to believe they happen all the time.

If management can get a real feel for the likelihood of an incident, it might well turn the project down and invest in a much more profitable area. Conversely, if it is led to believe that this bad situation exists continuously or even once a month, it may forego valuable investments in order to correct the infrequent trouble spots.

6. Don't Forsake "Bottleneck Removal." After being 100 percent certain that the first five principles are being applied to the maximum extent possible, then it is necessary to turn to minor capital alterations wherein existing equipment is debottlenecked.

Complete detail and over-all work should make it possible to have on the shelf, a number of capacity-increase projects, which can be installed with minimum time lag. This approach helps reduce pre-investment and assures better planning.

Perhaps these obvious principles should be applied to each of a com-

pany's current and future projects. Let's hear the real negative side of these projects. It is certainly possible that this negative approach will meet with disfavor and may well be wrong. On the other hand, it may provide a valuable re-evaluation on a number of projects. To demonstrate this, here are a few fictitious projects for example purposes only.

1. Additional Office Buildings or Laboratory Space. During a prosperous period, organizations tend to grow simply because a plant has grown in size and complexity. This plant growth may or may not mean additional work load. The actual situation may well be that the new modern equipment would have permitted reducing personnel. But nevertheless, business is better and more people are now on the payroll. More laboratory analyses are now being run. So what could appear more logical than to develop budget projects justifying more office and laboratory space?

Once these projects have been reviewed through several management levels and approved, then pure momentum will see to it that they are carried to physical completion—even though their justifications may be appreciably reduced by a decided drop in business activity before construction is even started.

The introduction of budget proposals for new office or laboratory space can provide the opportunity of reducing operating costs rather than increasing capital plant. This is possible if principle number five is applied. What are the future predictions of personnel in the light of reorganization, consolidation and review of present clerical procedures?

Are your clerical procedures the simplest? Is your organization really efficient and streamlined? Is existing office space properly utilized? Since the answer to all three questions is probably "no," new office space should be a difficult sale.

Are laboratory samples at a nonrepresentative peak? Can a careful study reduce the number of analysis required? How many laboratories run samples every eight hours from long standing habit, when, perhaps one or two samples per day is sufficient. Principle number three may tell you that the problem is too many unnecessary laboratory analyses instead of insufficient laboratory space.

2. Fire Protection in Tank Farms. Let us consider a modern tank farm of, say, 10 or 20 large tanks which are used for only fuel oil. Here is a real opportunity to violate principle number three—by providing multiple solutions to a single problem.

It is possible that large expensive water lines have been run out to the tank farm for fire protection, foam lines and foam chambers are installed from outside the firewalls to the tank roofs, tank spacing and firewalls are in accordance with the best standards. Lightning arrestors may also be on every tank.

Furthermore, the pumping and manifolding may permit the rapid transfer of the contents of a burning tank to another. The question is, "Were these special water lines and foam lines necessary in the light of the other factors such as the tank spacing, the unlikeliness of a fire in a fuel oil tank, the ability to transfer from one tank to another, etc?"

3. Installation of Marginal Equipment. Quite often in refining, it is found that installation of many types of marginal equipment are justified on a basis that might be called "impulse buying." Such equipment is usually to remedy a situation like:

A. Improving water removal

B. Reducing fouling of equipment

C. Increasing mixing or emulsifying

D. Increasing combustion efficiency, etc.

The need for such marginal equipment is usually marginal because surely the designer or builder took into consideration such deterrents as fouling, poor mixing, etc., and utilized the safety factors which he had available based on experience. Don't let "wishful thinking" dominate the situation. The well known statistical methods should be used to determine whether the use of such marginal equipment can contribute a significant or definite improvement.

Use of Efficiency Index as Guide. As a guide to following the trend of investment efficiency, an index can be used in a graphical manner. The index should be a straight calculation of barrels per day refined (or thruput) divided by some unit of plant investment. For example, it could be barrels per day per $10,000 of investment. A plot of this index for an historical period of time will demonstrate forcibly what your situation is as regards investment efficiency. If the trend is up, it's a good omen—but if it's down, it may mean trouble. However, all the trend can do is indicate direction. It is only qualitative.

You may compare it with other organizations to see which has the best "investment efficiency." But it is still only a qualitative tool. What every organization needs is something quantitative—something that can tell you how high you can go in "investment efficiency." To attain this goal is not easy because it requires attention to good engineering practices. This is why it is a good idea to rely on sound fundamental principles of engineering practice which can be helpful in any kind of investment situation.

In Conclusion. The six fundamental principles proposed in this article have been arrived at after much cogitation, embarrassment, soul searching, analysis of actual projects, and general discussion with men of long experience and practice. They are simple, logical and plain common sense. We think that if you put them to work in your organization you'll see some satisfying results.

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About the Author

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THE STORY BEHIND INTERGROUP CONFLICT

APPLIED GROUP DYNAMICS

Ever wonder why the people in one department always seem to be bickering with those in another—why some groups never seem to work well together? This article will tell you why—and what you can do about it

Robert R. Blake and Jane S. Mouton
The University of Texas, Austin

THE STUDY OF RELATIONS between groups is central for understanding and dealing constructively with many of the difficulties experienced in a refinery operation. Intergroup relations, as extremely important as they are, are almost totally ignored, or misunderstood, or disregarded in our time. Yet, no problem area is more important for managers to understand than the operating difficulties produced by competition between groups. It is difficult to overestimate the opportunities for enriched decision-making based on collaboration between groups. The study of applied group dynamics in a management development laboratory is an excellent place for acquiring the skills for doing it.

Intergroup Relations. There are many reasons for creating and studying intergroup competition, conflict, and cooperation under laboratory conditions. In fact, what we learn will even help us understand intergroup conflict of international, national, and even local group activities. One good example of this is the situation currently facing the United States and Russia, who for years have been struggling to come to some kind of a peaceful coexistence with mutually acceptable rules, under a 1/1 form of power relationship.

Another is the situation which faced the steel industry in 1959. Labor and management were deadlocked in a 1/1 power struggle for a strike of 116 days. In that situation labor persisted in demanding increased wages and benefits. Management insisted on its inability to provide them, and in turn counterdemanded for better and more flexible working arrangements with employes.

What happened? The government through the Taft-Hartley law, stepped in to create a 1/0 relation to both sides, enforcing collaboration between management and the work force by legal action! So it goes. We've yet to move out of the 15th century when it comes to intergroup decision-making without the application of authority-obedience.

What could be more important in management development than learning to deal skillfully with intergroup conflict and friction in order to resolve it with collaboration when it's appropriate, or intergroup competition when it's constructive?

Intergroup Competition. After a few days of meetings, development groups engage in competition. The goal? To see which group is the best, or most effective, in coming up with an original answer to a concrete problem. One group gains victory, another suffers defeat. From these experiences a manager has the chance to learn why, back home, people in one department won't talk with people from another, and he may learn some ways for improving the communication and decision-making between groups. Let's explore how issues of intergroup relations are studied in a laboratory, and then examine a few examples of pressures and tensions produced by friction between development groups.

During the initial phase, development groups meet as self-contained, self-steering, self-regulating units for a period of about 15 to 20 hours. Cohesion generates quickly during this time. Usually there is a lot of pride in membership. At this point groups enter the competition to determine which is the most effective in problem-solving. Members sense their ability to perform and their

status as an effective group is challenged when confronted with competition. The result? A strong motive to win, just as is true for any work group which is challenged.

Changes in Cohesion. Take cohesion, the solidarity or the morale of a group, as an aspect through which changes in group organization may be seen under conditions of competitive relations. At the end of each development group, members have indicated how "good" they think their group to be. The question is: "How do you feel about your group?" The answer is on a nine-point scale from "Worst possible" to "Best possible group." The same question also is answered at points along the way during the intergroup competition.

Figure 10 shows the feelings of cohesion reported by 12 different development groups, each block showing the results for two groups which are competing with one another. From Figure 10 it is apparent that development group members rarely think themselves to be as low as "average" even before competition is introduced. All groups rate themselves to be something better than "average."

Here in itself is an interesting phenomenon. What does it mean? It points to the natural "superiority complex" of groups. It looks as though people routinely think that the groups they belong to are at least a little above "average." This finding also is true in Figure 10. For the period of time before intergroup competition is begun, in almost all of the group ratings, or 60 out of 64 times, cohesion is scored as above "average."

Now then intergroup competition is introduced. What happens? Interestingly enough, 9 of the 12 groups show an even further increase in the degree they think their groups to be "good." Why is it that competition results in the enlivening of group life, in making members of a group feel it is even a better group than it was before it entered into competitive relations?

Here is an item of the first significance. It may even mean that people look for competition in order to feel closer to one another. Under competition they can close ranks and become more single-minded. Then they have a clearer goal: to win! Is this the way that members of management behave during a period of intense bargaining? Many managers say so. They point out too that this kind of human reaction—the closing of group ranks —increases difficulties of problem solving across group lines. Representatives of labor agree.

Changes in Influence. Leadership has been examined in many of the intergroup competition situations that have been studied. How? At the end of each meeting, members rank one another on the degree of influence exerted on the group action. Then the average development group influence rank of each member is related to his organizational rank in the refinery. Through this

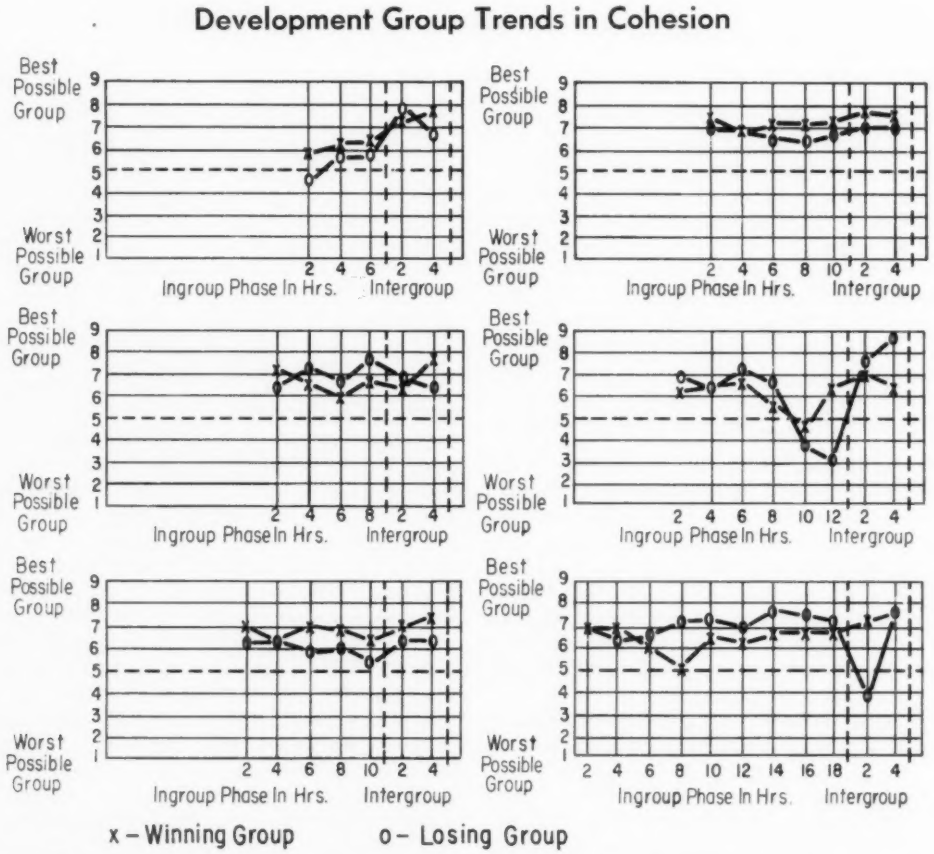


FIGURE 10—Members of development groups rarely think of themselves as low as average even before competition. This points to the interesting "superiority complex" of groups.

kind of study it becomes apparent, as noted earlier, that in the beginning of the development group, high influence is in the hands of those higher in rank in the refinery.

But the critical question to be answered is, "What happens to the influence positions of individuals under intergroup competition?" Figure 8 given earlier (PETROLEUM REFINER, Sept., 1960) shows the answer. At the time of crisis—with the introduction of intergroup competition—the high ranking refinery members come even more to the fore. They bang away and sharply increase their power, even beyond the amount they previously had.

In the eight cases shown in Figure 8, it is clear that group members with high refinery status become even more influential than they were prior to competition. Group members with low refinery status become less influential than they had been. These results have been confirmed in 26 or so competitions.

What do these findings indicate? They demonstrate that under conditions of competition, when the reputation of a group is at stake, persons of high rank tend to "take over." Those of low refinery rank let them do so and take positions which are more clearly those of followers.

A Tight Rein. Exploration of these results identifies many points of application for actual plant or office work. A common report is that managers often give "free rein" (0/1) to their subordinates when the situation is running smoothly, but then turn to "tight control" when the pressure is on. They become closer to 1/0. People of lower rank complain that this situation is a source of strong disturbance in business operations. They tend to lose the power to make decisions under conditions of pressure when they need it most! They also feel a lack of trust is shown by a higher management that "takes over" when the situation gets tough. Thus lower ranking persons feel weak and dependent and insecure among themselves; they don't "know" whether or not, or when, they're free to act on their own initiative.

Improved understanding between members representing different ranks in crisis situations will aid higher ranking refinery managers to assist those of lower rank in solving problems at times of pressure rather than "taking over" and doing it themselves. Awareness and avoidance of panic reactions of this general sort is a good example of the contribution of laboratory training to management development.

Distortion Tendencies. During the ingroup phase each group has two hours to develop its own solution to the assigned problem. The problem to be solved, in the form of a two page double-spaced typewritten memorandum of about 500 words, is equally within the experience of all members, whether high or low in organizational rank or whether technical or practical in background. A typical problem is, "Under what conditions in an organization is it appropriate to employ a .5/.5 power system and when is it appropriate to apply a 1/0 or an 0/1 approach?"

In a 32-man laboratory with four groups of 8 apiece, the usual procedure is to place pairs of groups in competition. However, they are not paired off for competition at this time. Solutions to the problem are reproduced and exchanged between groups, and a couple of hours are spent discussing and evaluating the merits of each of the four solutions on an ingroup basis. Members are urged to increase their understanding of their own position and of the other groups' position by noting points of similarity and difference, and points needing clarification or elaboration.

Results from this judging are in Figure 11. The dotted bars represent the average judgment by a group of its own solution as evaluated on a 9-point scale, with

Judgmental Tendencies for Solutions When Adversaries Are Not Identified

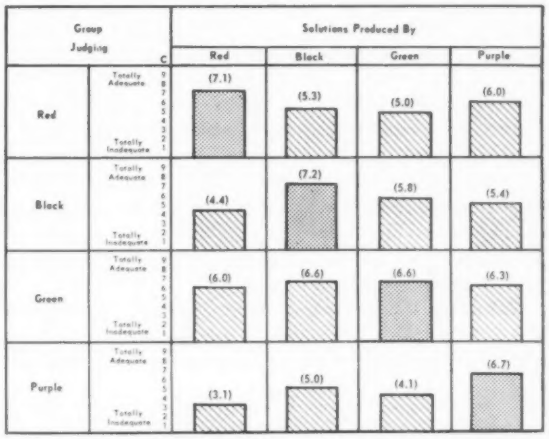


FIGURE 11—Significant trend is for group members to place higher assessment on their own group's product than on products other groups developed under same circumstances.

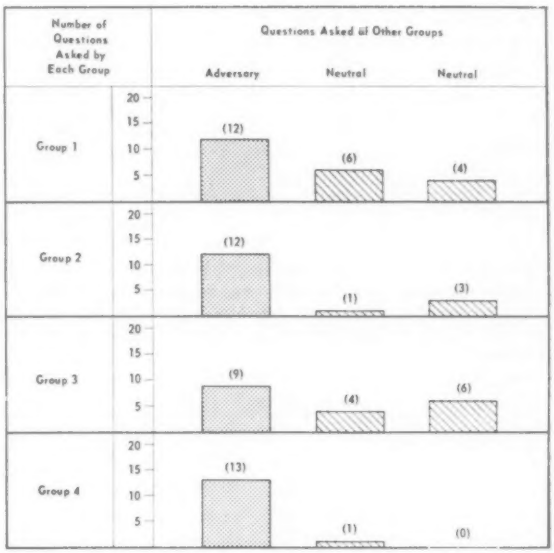


FIGURE 12—When provided the opportunity to challenge the quality of another group's product, neutrals are more or less disregarded, but adversaries are targets of attack.

scale intervals ranging from "totally inadequate," to "totally adequate." The bars with diagonal hash marks represent each group's evaluation of the reports submitted by the other three. The situation of judging is arranged so that each solution is evaluated by another as often before judging one's own group's solution as it is afterward. This is done to cancel out "order effects."

Clear-Cut Results. They show that group members universally prize their own solutions as being higher in quality than they value the solutions by the three, unidentified, competing groups. This is seen in the dotted bars running from the upper left to the lower right side of Figure 11. In only one (the Green group) of the 12 comparisons is another group's solution accorded the same quality as the rating group.

What do results such as these indicate? They clarify the general idea that group members have a strong identification with their own position, and that they

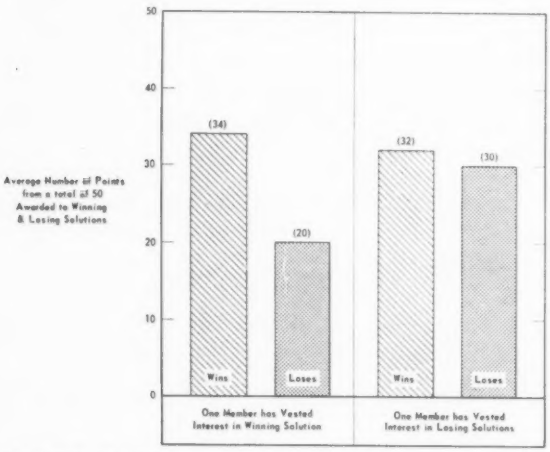


FIGURE 13—When one member has vested interest in the winning solution, and the other has no interest, judging presents no problem. However, when one member has a vested interest in the losing solution, he refused to give up without a struggle.

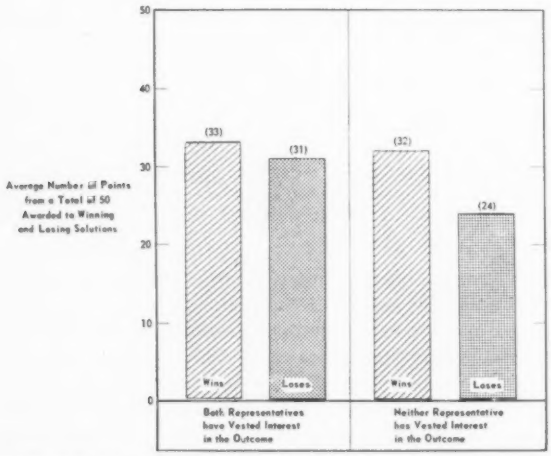


FIGURE 14—Representatives with vested interests are unable to agree on differences in the quality of two solutions; those without vested interests can agree on differences in the quality of the two solutions.

tend to reject, or to downgrade the solutions produced by other groups. Even though two plants are more or less equal, if a person is a member of plant X, chances are he thinks it's superior to plant Y, and is able to do a better job, all other things considered!

"Ping" the Adversary. After completion of the judging phase just described, solutions are identified by groups. Which pairs of groups will be in competition is also announced. Then there is an additional period of clarification in which groups are encouraged to address questions to any of the other three for purposes of clarification.

To which groups, the adversary or the two neutrals, are the largest number of questions launched? Figure 12 gives a straight-forward answer. As you see, the neutrals are *disregarded*—the adversaries are *challenged*. Group 1, for example, asked 12 questions of its adversary, but only 6 of one neutral and 4 of the other. The comparable values for group 2 are 12, 1, and 3; for group 3, they are 9, 4, and 6. Group 4 shows the trend most dramatically. Values here are 13, 1 and 0!

What do such results mean? The indications are all too obvious. Groups challenge, ping, pick at, and push at other groups who are threatening to them. However, they tend to ignore and disregard other groups they feel neutral toward. Furthermore, trends are independent of the quality of solutions!

The analogy of this trend is evident in the United Nations. Countries that feel competitive tend to belittle each other's positions while ignoring proposals submitted by other countries which stand as neutrals—even though these proposals may be of equal or superior quality. A similar analogy can be drawn using the typical reactions in a company representation election. The two strongest groups, from the standpoint of representing wage earners, are likely to launch attacks on one another, and at the same time disregard the position being proposed by other groups which don't have sufficient strength to be considered "threatening." The target of a group's attack, in other words, is whatever other group is considered its strongest adversary, not whichever other group seems to have the "best" solution!

Interests of Members. Another way of evaluating intergroup competition is to study how group membership effects the behavior of its individual members. Thus, it is interesting to observe reactions of two persons who are asked to judge two solutions when:

1. Both are "vested," *i.e.*, the persons composing the pair are from competitive groups.

2. Only one member of the pair has a vested interest, *i.e.*, his group's solution is being judged in comparison with another solution, but the other member of the pair does not come from the group which wrote the second solution.

3. Neither member of the pair has a "vested" interest in the outcome, *i.e.*, neither solution is from a group from which either member comes.

Results for these conditions are shown in Figures 13 and 14. Clear conclusions are apparent.

When one member has a vested interest in the solution that wins and the other has no vested interest because his group's solution is not being evaluated, judging presents no problem. They can get together and come to

quick agreement, correctly awarding the highest point total, 34, to the solution "owned" by the vested member and giving only 20 points to the other solution. However, the other side of Figure 13 shows the opposite side of the story. Here the vested member refuses to "give up." He is able to "get" the uninvested person to give many more points to his solution than would otherwise occur.

Figure 14 tells the same kind of story. It says individuals are unable to agree when both have a vested interest, but, as seen on the right side of Figure 14, they have no difficulty getting together when neither member has a vested interest.

These several comparisons show in a crystal clear manner that group members have difficulty in disentangling objective attitudes toward a proposal from attitudes that are saturated with membership emotions. It is for this reason that managers are likely to render biased judgments whenever the problem of appraising a proposal is contaminated with vested interests.

Knowledge of Own Group's Solution versus Knowledge of Other Group's Solution

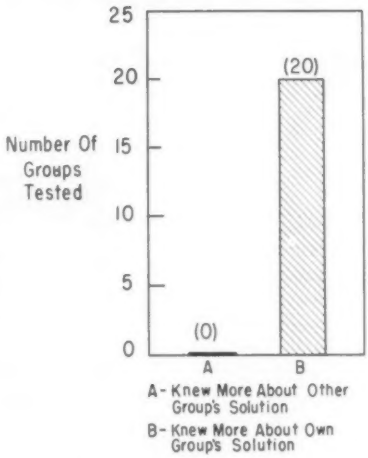


FIGURE 15—Even after intensive study of other group's solution, group members of the opposing group do not understand it as well as they understand their own.

Kinds of Errors on Common Items from Intergroup Knowledge Test

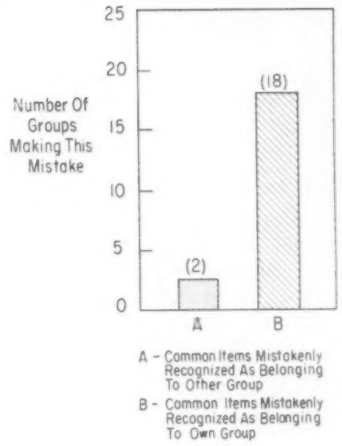


FIGURE 16—What two groups actually share in common is difficult for group members to recognize.

Knowing the Others. When competition is between groups each of whom has its own fixed position, an individual's identification with his group makes it difficult, if not impossible, for him to clearly understand the opposition's position. A result can be that intergroup problem-solving is even more difficult because the groups don't even know the differences that exist between them. When the victory in any intergroup competition is based on the quality of proposals, each side must have accurate knowledge of the position taken by the other. Without accurate knowledge of the opposing group's product, a verdict of victory or defeat is likely to produce invidious reactions and unrealistic attitudes.

It seems only reasonable to suppose that when two groups are given adequate opportunity to study and evaluate their own proposal and the proposal of the competing group, there should be no logical reason why differences in accuracy of knowledge of the two proposals should develop. Yet distortion tendencies in judgments of both groups' products do occur. Tendencies toward favoring one's own solution over others already have been discussed. However, intergroup competition provides an excellent opportunity to investigate these distortions.

Results from 20 groups studied under competitive conditions show that members actually know more about their own solution than about the one submitted by a competing group. The results of this study are shown in Figure 15. In no case has a group known less about its own solution than about that produced by the competition. These results can only mean one thing: intergroup problem-solving is more difficult than it should be, if for no reason other than that people have trouble understanding the position of a competitive group.

As seen in Figure 16 another analysis that can be made is of the common items—ones that are contained in both solutions. These items are frequently missed. The tendency is to attribute the item to one's own group's solution only and not to recognize that it is contained in the proposal of the competing group as well. It's as though groups fail to grasp what they share in common; they're more interested in what it is that separates them. Here is a generalization of great importance, for it says groups tend to act towards one another as though they had "blinders" on. How can you expect collaboration if understanding is absent, or even worse, if misunderstanding is present?

Here then are two findings of paramount significance in determining barriers to the resolution of conflicts between groups. Under competitive conditions members of one group perceive that they understand perfectly the other's proposal, when in fact they do not. Thus, this inadequate understanding makes it all the more difficult for competing groups to view each other's proposals realistically.

Areas they share in common are likely to go unrecognized and in fact be seen as being characteristic of one's own group only. Under conditions of competition, then, distinctions are sought for and areas of true agreement go undiscovered. A manager needs to understand these basic reactions to group membership if he is to deal constructively with problems of intergroup relations that come under his jurisdiction.

TO BE CONTINUED

Test Yourself on Labor Relations

No. 1 – Literature Distribution

The company's contract provided for union bulletin boards so the labor organization could communicate with members. A clause in the contract limited use of the boards to such things as announcements of meetings, election of officers, recreational and social affairs to be run by the union. In addition there was this proviso:

"there shall be no distribution of political or advertising matter or other literature on the company's property."

The company decided to install a reading rack which contained pamphlets on economics. The aim was to make employes more aware of some of the pressing issues of the day. The booklets included such titles as "Reform Our Tax Rates"; "How Profits Affect Your Pocketbook"; "What Union Members Write To Senator McClellan," etc.

"You can't do that," said the union. "We have an agreement with you that no political literature will be distributed on company property. These racks are on company property, so take them off. Otherwise, let us distribute our kind of economic materials to the employes."

At arbitration the company said it had every right to distribute whatever it wished. The union has no right to dictate what kind of material the company can hand out to workers—as long as the stuff was not illegal under the Taft-Hartley law.

Test Yourself:

Was the company: Right ☐ Wrong ☐

No. 2 – Demotion a Legal Punishment?

It was a holiday but foreman Janis needed the maintenance crew. The men didn't want to come in and the biggest "beefer" of all was Walter Raskin, leader of the crew. His job was to hand out work, check up on progress, and report to the supervisor.

In this emergency the work didn't get done on time. Foreman Jones felt this failure was caused by Raskin's attitude. The supervisor decided to teach Raskin a lesson by demoting him to a line operation at a 15-cent an hour cut.

The company backed up Jones' action. Raskin's defense at arbitration: "You can't use a demotion as a way to discipline an employe."

Test Yourself:

Was Raskin: Right ☐ Wrong ☐

No. 3 – Can Employer Cut Coffee Break?

For 3 years the employes were allowed two coffee breaks a day—one in the morning and the other in the afternoon. At each break the workers left their jobs. As time went on, many abuses developed. The most serious problem was that of workers returning late to machines and desks. So management decided to cut out the coffee break. Instead, it substituted a "coffee cart" that toured the plant so employes could get their coffee on the job. There was a howl of protest. Workers complained:

1. The coffee break is a working condition and you can't just take it away at will.
2. A coffee break is established practice in industry.
3. The new service is not an adequate substitute. We want to leave our work to drink coffee.

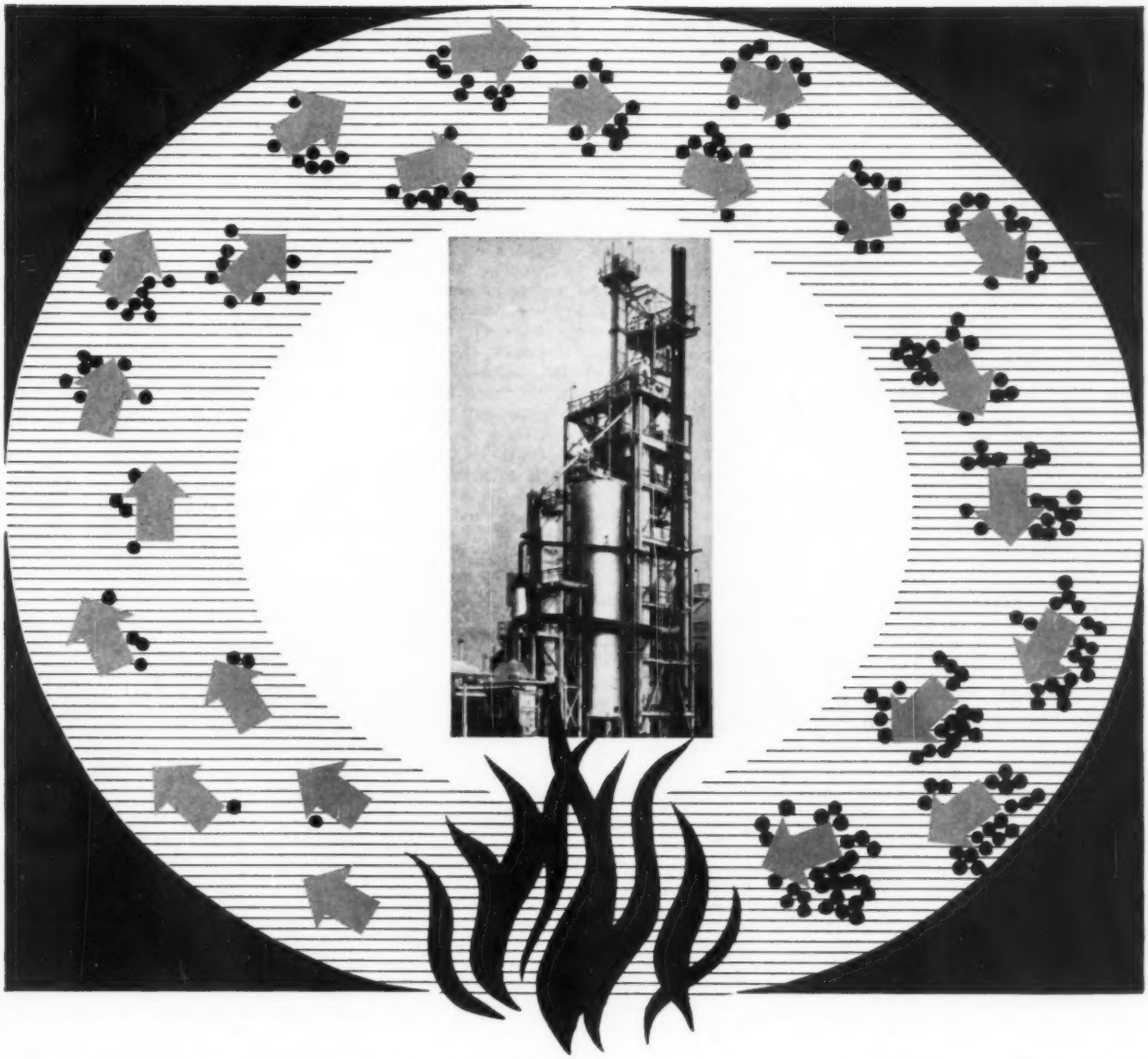
Management took time out to answer:

1. A coffee break is not a "right." We gave it voluntarily. What we give we can take away.
2. A coffee break is for coffee. This we are supplying through the "rolling" lunch wagon.

Test Yourself:

Was the company: Right ☐ Wrong ☐

Answers on Page 295



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"Polystyrene" provides a simplified yet technically accurate introduction to the chemistry, properties, manufacture and uses of polystyrene. Major emphasis throughout is on the applications of polystyrene materials by injection molding, by extrusion, by vacuum forming, and as a foam. The author includes the latest information on the uses of polystyrene in appliances, electronics, building, packaging, housewares, toys and novelties, transportation and furniture. One chapter is devoted to the manufacture, fabricating techniques and various uses of expandable polystyrene.

The book contains material of interest to research workers, such as a new approach to the evaluation of the effects of polymerization temperature on molecular weight and new information on the copolymerization of styrene and alpha-methylstyrene. Primarily directed to molders, fabricators and end-users of polystyrene, this book presents a working guide to the major procedures for producing this versatile plastic.

(Teach, William C.; Kiessling, George C., *Polystyrene,* Reinhold Publishing Corp., 430 Park Ave., New York 22. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, 176 pages, $5.)

Organic Compounds

"Tables for Identification of Organic Compounds" is a supplement to the Handbook of Chemistry and Physics. It has been prepared to assist chemists with the identification of organic compounds. A compilation consisting of more than 4,380 parent compounds, the book brings together for the first time a large quantity of data directly applicable to qualitative organic analysis.

Included in the tables are the main representatives of the more common classes of organic compounds. Among these are alcohols, alkyl halides, aromatic hydrocarbons, aryl halides, aldehydes, amines, amino acids, carbohydrates, carboxylic acids, carboxylic acid anhydrides, carboxylic acid halides, ketones, nitro compounds, nitriles, ethers, quinones, phenols and sulfonic acids.

(*Tables for Identification of Organic Compounds,* Chemical Rubber Publishing Co., 2310 Superior Ave., N. E., Cleveland 14, Ohio. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, 241 pages, $7.)

Operating Costs

"Bibliography of Investment and Operating Costs for Chemical and Petroleum Plants January-December 1959" is a continuation of the series of cost bibliographies which was initiated with the publication of Information Circular 7516 in October 1949. The present report covers the period from January 1959 through December 1959. The abstracted articles, concerned with all facets of cost engineering in the field of petroleum and chemical plants and related facilities, were obtained from the following sources:

- Bureau of Mines Information Circulars.
- Bureau of Mines Report of Investigations.
- Chemical Engineering.
- Chemical Engineering Progress.
- Chemical Week.
- Coal Age.
- Coal Utilization.
- Cost Engineering.
- Industrial and Engineering Chemistry.
- Nucleonics.
- Oil and Gas Journal.
- Petroleum Engineering.
- PETROLEUM REFINER.
- World Oil.

(Katell, Sidney; Faber, John H.; Douglas, John W., *Bibliography of Investment and Operating Costs for Chemical and Petroleum Plants January-December 1959,* U.S. Government Printing Office, Washington 25, D. C., 68 pages, 40¢.)

X-ray and Chemistry

"X-ray Absorption and Emission in Analytical Chemistry" has been written specifically for the analytical chemist who wants to understand and use the modern methods of x-ray spectrochemical analysis, employing x-ray absorption or x-ray emission. The book describes the history and underlying theory, the reliability of x-ray emission methods, a variety of applications, and all the necessary equipment and techniques.

(Liebhafsky, H. A., Pfeiffer, H. G., Winslow, E. H., Zemany, P. D., *X-ray Absorption and Emission in Analytical Chemistry,* John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 357 pages, $13.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.)

Maintenance & Engineering

"Techniques of Plant Maintenance & Engineering—1960" is a report of the Plant Maintenance & Engineering Conference held earlier in the year at Philadelphia. This volume is the largest in the 11-year series. In it are reprinted the 34 papers presented at the 1950 conference, along with the text of all the discussions, comments and questions asked from the floor and the answers from

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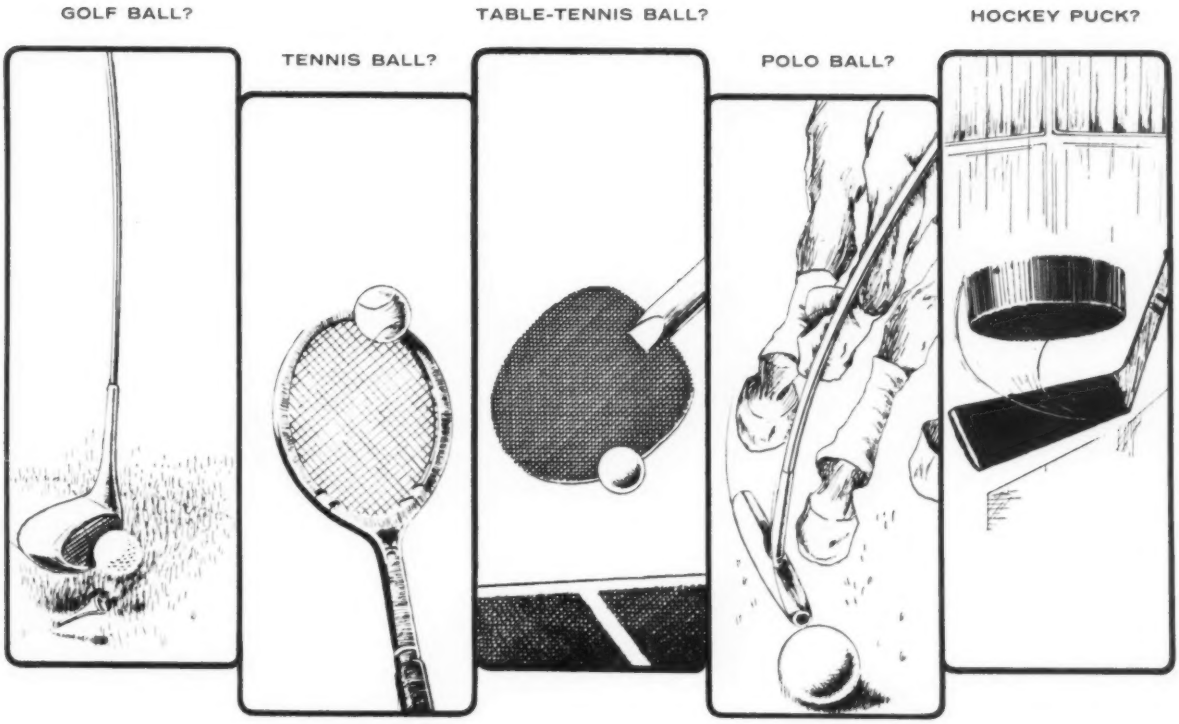

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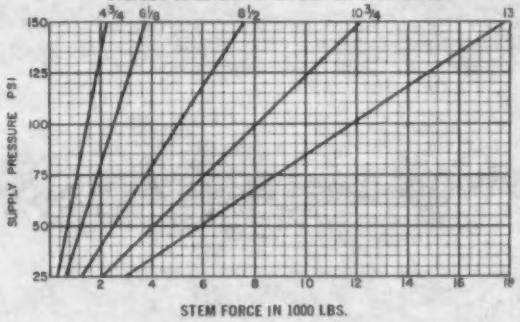

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- Interior hollow metal door, pressed steel doors, aluminum doors & frames
- Erect steel and aluminum sash
- Brick and marble floors and walks
- Marble wainscot, ceramic tile
- Terrazzo, mastic floors
- Quarry tile and wood block flooring
- Furring and grounds, lathing
- Metal lath, plastering, stucco
- Gunite and parging, acoustical tile ceiling
- Asphalt, tar and gravel roofing
- Insulation board and flashing
- Concrete roofing and roofing items
- Metal and wood roofing
- Entrances, canopies, building fronts and metal clad plywood facing
- Exterior iron and steel, masonry, concrete and stucco
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- Equipment foundations
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- Common brick walls
- Double size common brick walls
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speakers and panel members.

The round tables included in the text are those of chemical plants, petroleum processing plants and rubber mills and rubber products plants.

(*Techniques of Plant Maintenance & Engineering*—1960," Clapp & Poliak, Inc., 341 Madison Ave., New York 17, N. Y., 341 pages, $10).

Meter Measurement

"Measurement of Petroleum Liquid Hydrocarbons by Positive Displacement Meter" is an updated standard on the installation of meters, meter provers and their calibration, meter proving procedures and meter performances. The publication includes a section on the operation and maintenance of metering systems as well as some 100 terms and definitions related to meter work.

(*Measurement of Petroleum Liquid Hydrocarbons by Positive Displacement Meter,* American Petroleum Institute, 1271 Avenue of the Americas, New York 20, $3.)

Toxicological Reviews

"American Petroleum Institute Toxicological Reviews on Benzene, Toluene and Xylene" includes reviews of properties and characteristics, manufacture and probable conditions of exposure, toxicology, precautionary measures and a bibliography. The work was prepared by Philip Drinker of the Harvard School of Public Health and was reviewed by the API committee.

The new review and a second edition on copper naphthénate, naphthalene, naphthenic acids and butadiene may be obtained from the API.

(Drinker, Philip, *American Petroleum Institute Toxicological Reviews on Benzene, Toluene and Xylene,* American Petroleum Institute, 1271 Avenue of the Americas, New York 20, 25¢.)

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How to Do It...

Chart Selects Allowable Pipe Span Between Supports

Formula presents a convenient means for calculating pipe spans quickly and accurately

When it is desired to run pipelines on supports above the ground, the engineer must often calculate the allowable pipe span between supports from a structural viewpoint. Since a pipeline supported at various points is in essence a continuous beam, a formula for the span length can be obtained by equating the maximum bending moment caused by the loading to the resisting moment of the pipe. This formula is:

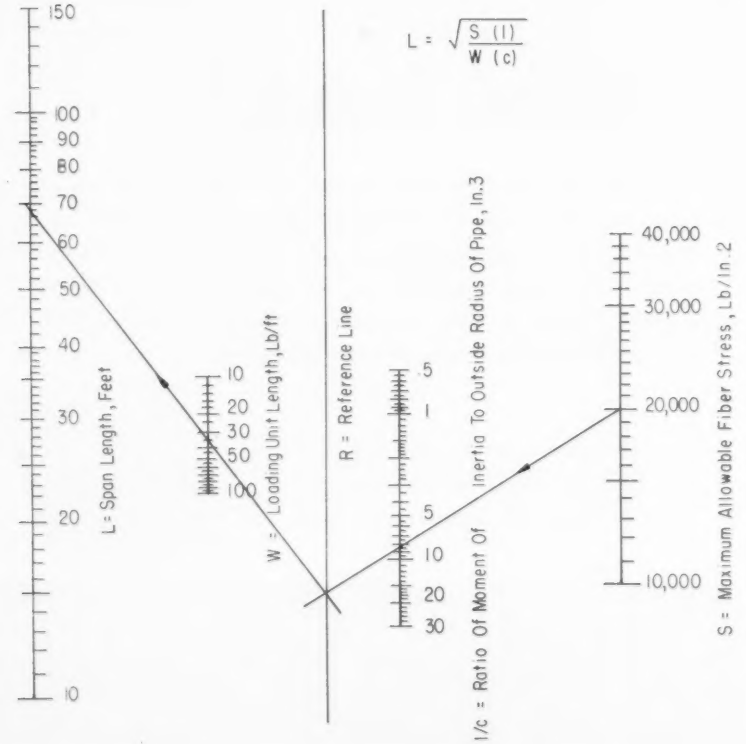
$$L = \sqrt{\frac{S\,I}{w\,c}}$$

where:

L, span length, ft.
c, radius to outside of pipe, in.
I, moment of inertia of pipe in.^{4}
S, maximum allowable fiber stress of material, lb./in.^{2}
w, uniform loading per unit length of pipe, lb./ft.

The above formula applies to pipes above two inches in diameter. Reference 1 gives calculated pipe span data as well as estimated pipe loading for different pipe diameters taking into account the fluid load, dead load, and the horizontal component of the wind loading.

The figure presents a convenient means of calculating the pipe span length quickly and with good accuracy. It is based on the equation given above.



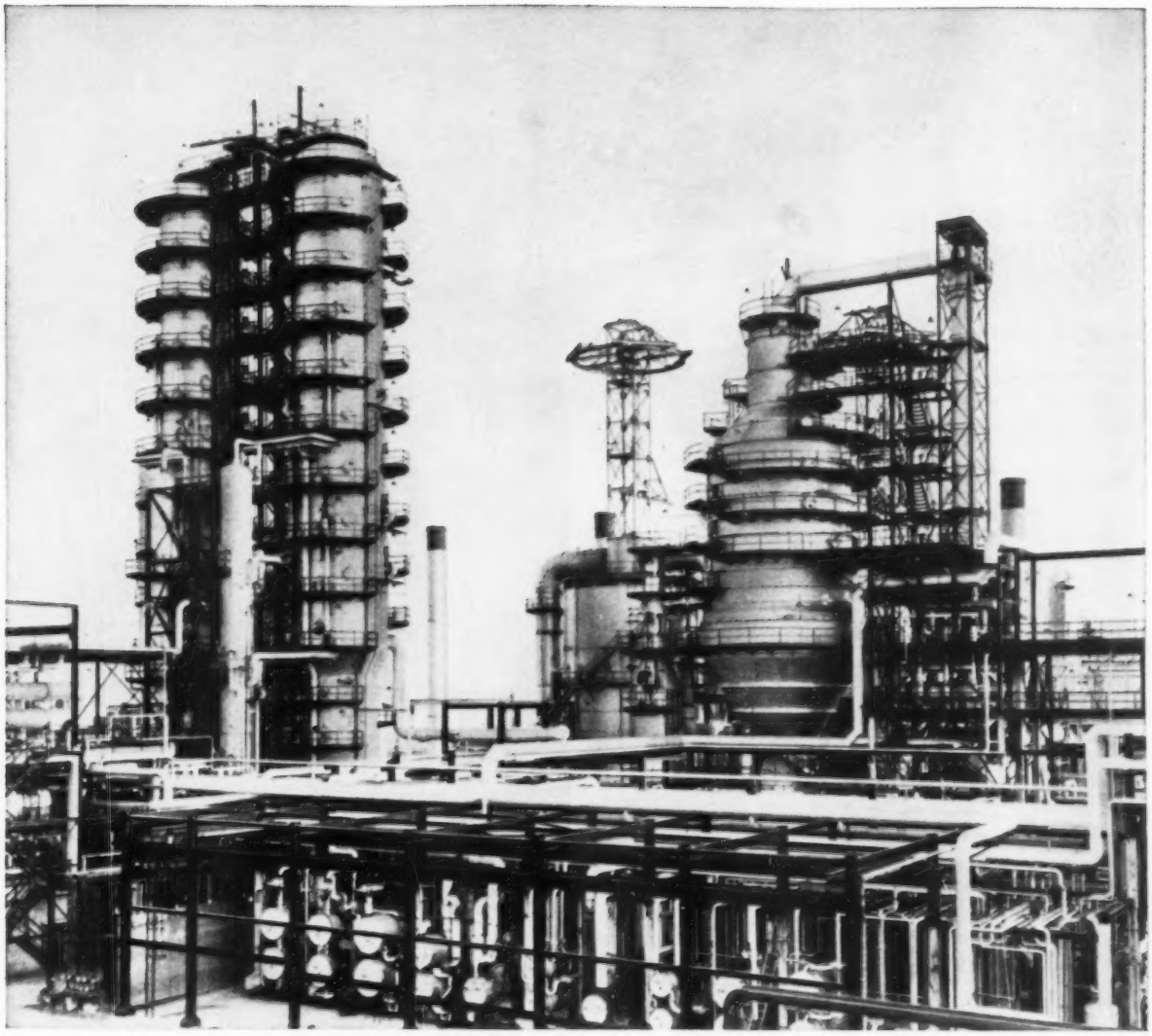
Example. Find the allowable span length for a 6-inch continuous steel pipe strung between supports. The estimated loading (sum of pipe, fluid, dead and wind loads) is 36 lb./ft. The allowable fiber stress for steel can be taken at 20,000 lb./in.^{2}

Solution. From any suitable handbook, c for a 6-inch pipe is 6.625/2 = 3.3175 in., I is 28.14 in.^{4} Now, calculate I/c = 28.14/3.3175 = 8.5 in.^{3} Connect S = 20,000 lb./in.^{2} on the S scale with 8.5 on the I/c scale to the intersection with the reference line. With the reference line as a pivot, connect the pivot point with W = 36. At the intersection with the L scale, obtain a pipe span of 68 feet.

Item submitted by J. F. Kuong, Atlas Powder Co., Wilmington, Del.

Reference

1. Sweeney, R. J., Chem. Eng., 63, No. 3 199 (1956).



For economical protection from acid condensates, Monel Hortonclad is used in 13 ft diameter vapor top of vacuum column (right) and in upper portions of two 174 ft atmospheric crude columns (left), at the Marcus Hook Refinery of Sinclair Refining Company.

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Huntington 17, West Virginia

MONEL®

For more data on advertised products, use Readers' Service Cards, last page.

ADDED VALUES

QUALITY CONTROL

Quality control influences every G.E. operation, from order receipt to shipment.

PRODUCT INNOVATION

Product research and development is advanced in all 98 G.E. laboratories.

System Planning

Customer-oriented application engineers assist you with systems integration.

ANALYTICAL ENGINEERING

The latest tools of process analysis are available for studies of your problems.

INSTALLATION AND SERVICE ENGINEERING

Expert on-site assistance gives you smoother installation and earlier start-up.

SYSTEM CO-ORDINATION

G.E.'s systems experience focuses the full Company capabilities on your order.

NATION-WIDE SERVICE SHOPS

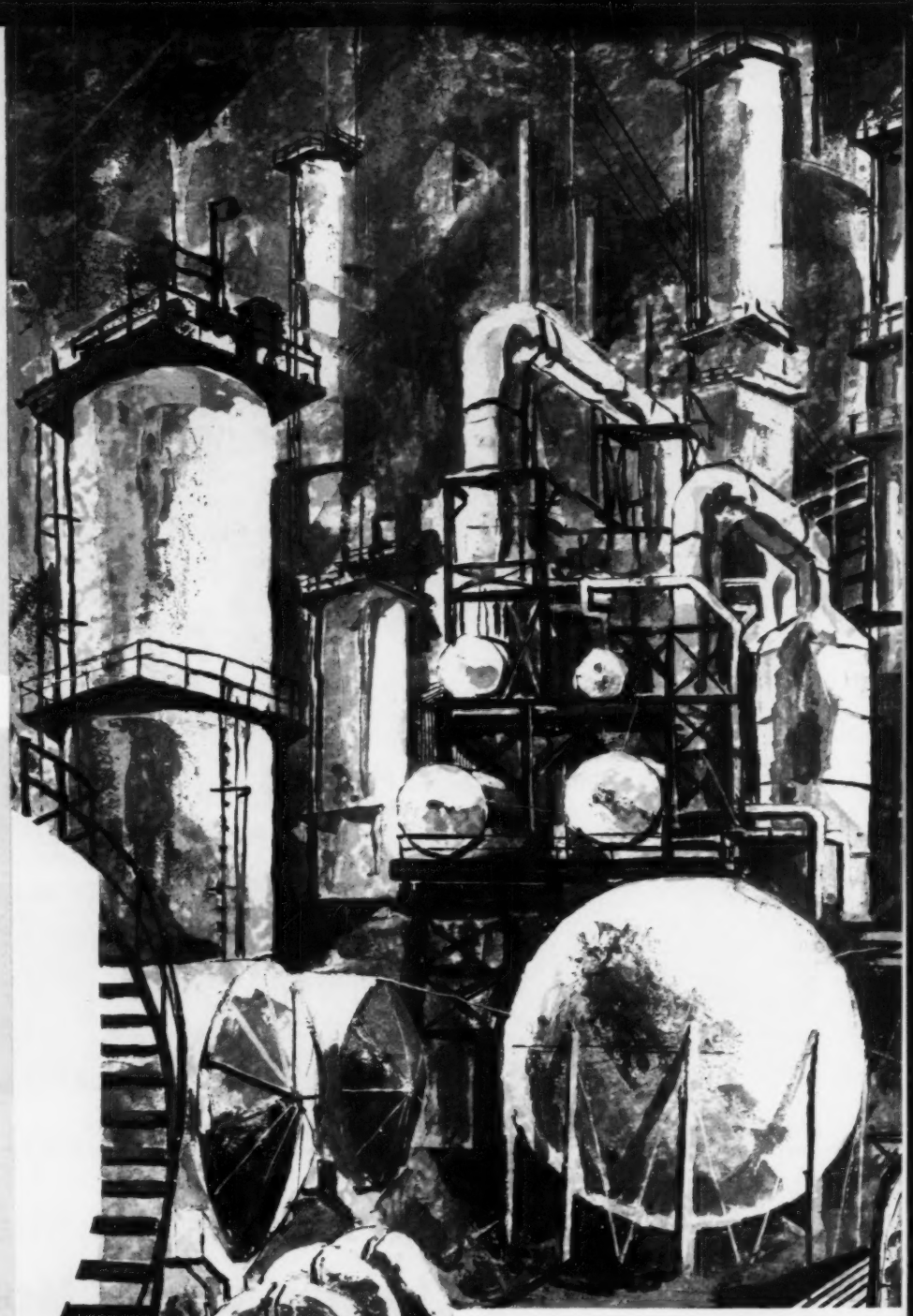
More than 50 G.E. Service Shops offer you 'round-the-clock maintenance service.

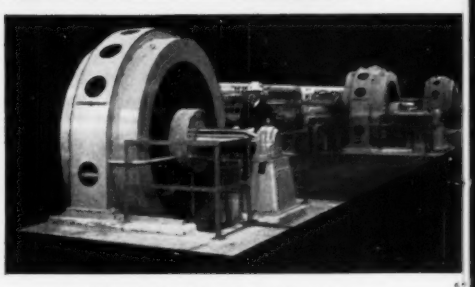
PROMPT DELIVERY

Accurate delivery cycles put your new G.E. equipment to work for you—on time.

VALUE ANALYSIS

Value Analysis gives you optimum combination of product value and economy.





G-E SYNCHRONOUS MOTORS give you lowest-cost shaft power for many compressor and blower applications. Initial cost is low, efficiency is high, and installation is fast and inexpensive.

How General Electric System Planning Helps You Reduce Process Costs

Today's cost squeeze in the petroleum and chemical process industries can be minimized when the experience and know-how of General Electric system planners is used in selecting your key process drives. G-E system planners will analyze your processes and help you design systems in which equipment capabilities are efficiently and economically matched to your particular process requirements. By taking advantage of G-E engineering assistance during the earliest planning of your new processes, you will be able to give well-defined systems guidance to your engineering contractor or consultant.

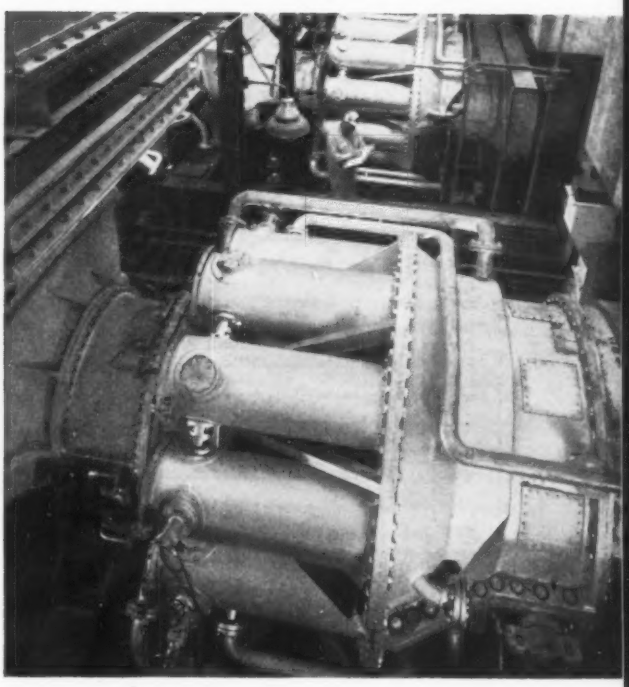
FOR EXAMPLE, GENERAL ELECTRIC SYSTEM PLANNERS recently recommended three gas turbines to drive key compressors and blowers at a new ethylene process plant. These three 13000 hp G-E turbines are not only providing reliable shaft power but also a power bonus by economically supplying hot gas for heating process air and making steam. Designing such flexible, cost-saving equipment into your process system at the very beginning can also reap big operating benefits from your investment.

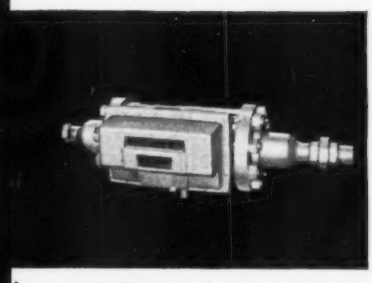
FOR DETAILED INFORMATION on how General Electric system planning can help reduce your process costs, call your local General Electric Industrial Sales Office. General Electric Company, Schenectady 5, N. Y. 651-02

Progress Is Our Most Important Product

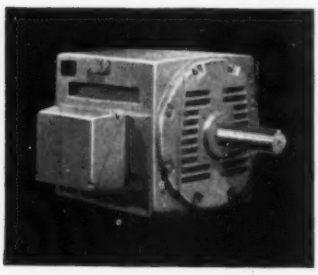
GENERAL ELECTRIC

GENERAL ELECTRIC GAS TURBINES recently installed at a new ethylene process plant are providing reliable, continuous service plus a power bonus by supplying hot exhaust gases for making process steam. Application of G-E gas turbines in your process system can provide similar operating benefits.



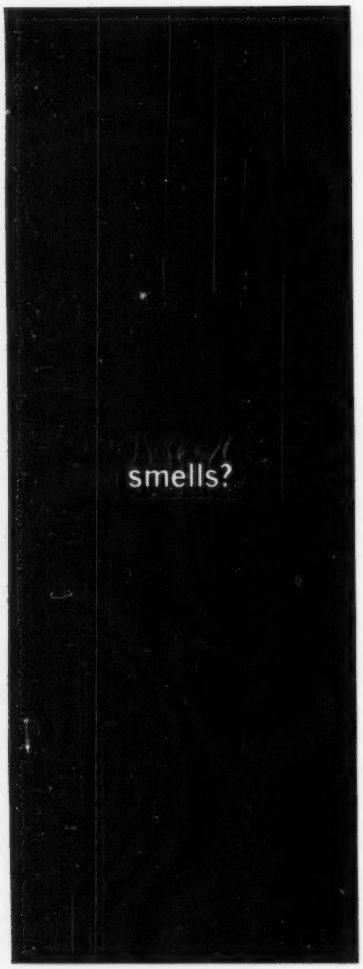


NEW TRUE MASS FLOWMETER measures fluid streams directly in pounds, eliminates the time-consuming—and sometimes erroneous—conversion of volume to weight.



NEW CUSTOM '8000'* motors with special Polyseal* insulation systems may permit you to use lower-cost enclosures.

*Trade-mark of General Electric Co.



Call on Rhodia "Odor Engineering" to solve your malodor problems in plant or product

Rhodia Inc. is the world leader in industrial odor control and reodorization technology and a primary producer of industrial aromatic chemicals. It offers fully qualified consultation service anywhere in the United States without cost or obligation.

RHODIA INC., 32-8
60 East 56 St., New York 22, New York
Gentlemen:
Please send me Rhodia literature.
My problem is: (please give specifics)

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NAME_____

ADDRESS_____

CITY_____ STATE_____

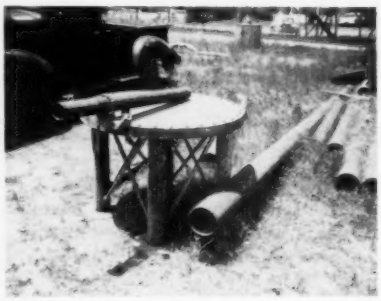
RHODIA INC.
60 East 56 St., New York 22, New York
(Phone: PLaza 3-4850)

How To Do It . . .

Manhole Cover Makes A Handy Work Bench

A field work bench which will serve as an anvil and provide an easy place to install a vise can be made from a discarded manhole cover.

Pieces of four-inch pipe are welded to the bottom of the cover and braced with one-inch pipe forming an



X between the legs. Circular plates are cut from one quarter-inch scrap plate and welded to the pipe legs for a firm footing. The vise can be easily mounted by extending the anchor bolts so that they will reach through the thick metal of the manhole cover.

Blotting Paper Filters Water Out of Lab Samples

Routine process samples frequently contain traces of water on arrival in the laboratory. When these traces are due to the condensation of water vapor, they are finely emulsified and settle out very slowly if at all. This water must be removed before testing in many cases, e.g., before testing gasoline or other distillates for color as even 100 ppm of water can seriously interfere with the results.

Simple filtration can effectively dry the sample but the cost of filter paper can become a significant item if a large number of tests are to be carried out. In such cases, a cheap grade of blotting paper can be used as filter paper and it possesses the advantage that can be more efficient, as the thicker paper can hold more water.

With heavier samples such as middle distillates and light to medium lube fractions, it is sometimes quicker to filter the oil through a plug of cotton wool. The plug is firmly inserted in the neck of the funnel to prevent the oil from by-passing it and just sufficiently thick enough to hold back the water. Very little experience is needed to fit such a plug more quickly than it takes to fold and fit a paper.

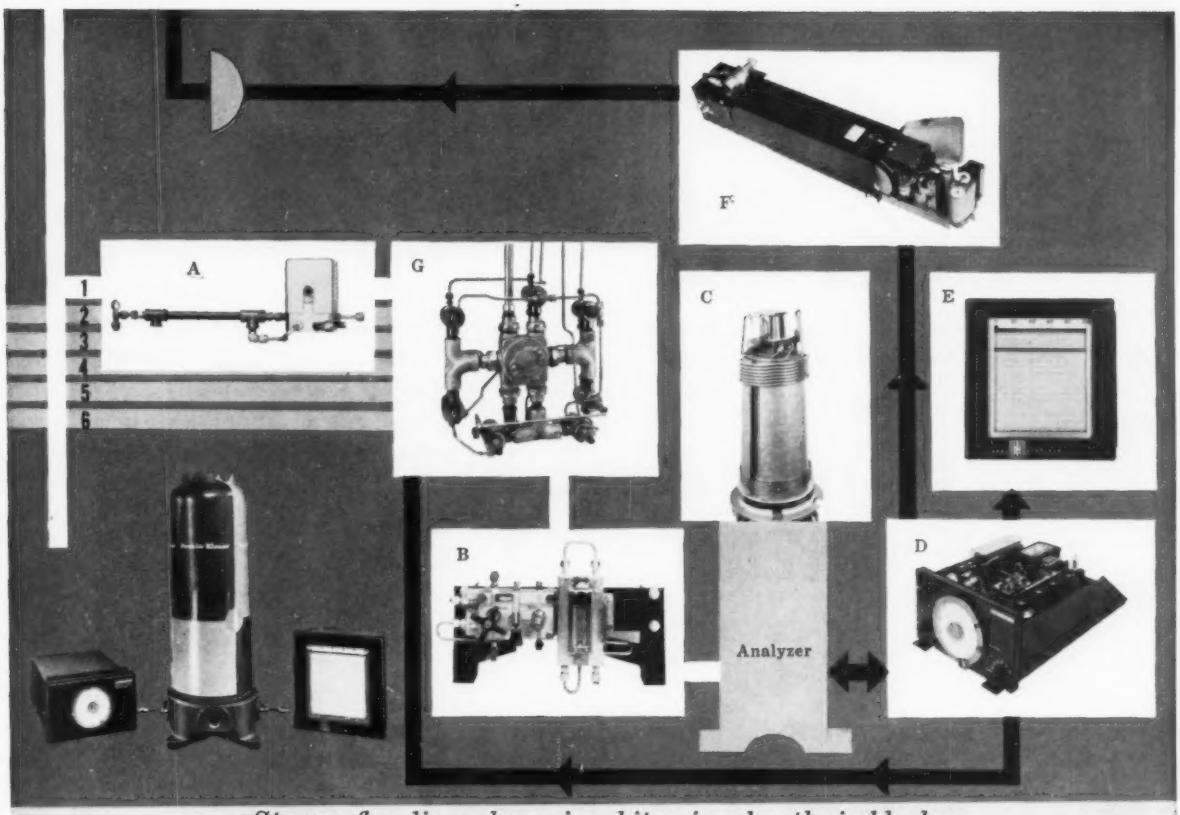
Item submitted by Geo. E. Mapstone, Johannesburg, South Africa.

Simple Heat Exchanger Cools Feed Water Sample

The collecting of feed water samples can be troublesome and even dangerous unless there is a means of cooling the sample before it is collected. One refinery superintendent rigged up the illustrated sample pot so that water from the plant cooling system circulates at all times through a coil of copper tubing inside the pot, which effectively cools the sample before it is exposed to the air. If it is

$$ Your Ideas Are Valuable! $$

At least $10.00 will be paid for each idea accepted for "How To Do It." All you need to do is write a brief note telling about your idea, then attach a photo or sketch (if needed), and mail it to Editor, Petroleum Refiner, P. O. Box 2608, Houston.



Stream flow lines shown in white, signal paths in black

This block diagram shows how six process streams can be selectively analyzed by the P-E Model 184-B. For brevity, Stream #1 only will be followed through the system.

Stream #1 is tapped, and the sample vaporized in the Liquid Sample Vaporizer (A). Sample #1 then flows (with the other five vaporized samples) into the enclosed, heated Multi-Stream Solenoid Switching Manifold (G). The solenoids are electrically directed by the Programmer (D). As it is selected, Sample #1 is valved into the Final Sampling Assembly (B), where it is filtered and metered into the Analyzer. The Analyzer quantitatively and qualitatively separates the sample's components by gas chromatography, produces signals which appear as a bar graph on Recorder (E).

The signal can also be fed into a Pneumatic Control Accessory (F) which produces a 15 psi signal for automatic control of one variable component of the stream.

The Analyzer with Reverse Flow Valve (C) allows for the analysis of light components individually plus a "total heavies" measurement; it back-flushes and analyzes heavy ends as a single peak, shortening analysis time in the process. The Programmer (D) is available in a variety of modes for multi-component and multi-stream analysis. It controls the Switching Manifold (G) and the Analyzer, and the readout of the Recorder (E).

All flow lines and sampling building blocks are kept above the dew point, where necessary, by steam tracing.

UNTIL NOW—PROCESS CONTROL INSTRUMENTATION LIKE THIS HAD TO BE CUSTOM-BUILT

Standard building blocks give the new P-E Model 184-B Process Vapor Fractometer the flexibility of the most advanced special engineering developments in process gas chromatography.

A new, highly versatile instrument, the Model 184-B brings automatic process control by gas chromatography within the reach of virtually any petroleum or chemical processing plant.

The Model 184-B uses *building block* sampling and sensing units in various combinations to produce process analytical systems which mean continuing extra dividends through reduced maintenance, low-cost training and highest reliability.

These standard building blocks include multi-port sampling valves for backflushing and analyzing heavy ends . . . versatile multi-column systems . . . multi-stream programmer kits . . . pneumatic units for automatic control . . . and a wide variety of sampling devices.

Perkin-Elmer, the world's largest manufacturer of gas chromatographic instruments, will help you in your process instrumentation requirements. For more information, write for a new descriptive booklet.

All building blocks in any P-E system conform to standard refinery and chemical plant safety practices.

Talented engineers and physicists at all levels interested in development of commercial laboratory scientific instruments find great reward at Perkin-Elmer. Please write or call Mr. Howard Moran.

INSTRUMENT DIVISION

Perkin-Elmer *Corporation*

NORWALK, CONNECTICUT

For more data on advertised products, use Readers' Service Cards, last page.

New

B&W REFRACTORIES FOR THE PETROCHEMICAL INDUSTRY

B&W's line of refractories has been enlarged by the addition of new heavy duty firebrick and new ramming mixes. These new products, now offered after many years of developmental and field experience, are specifically designed for superior service in carbon black furnaces, butadiene reactors, reforming furnaces and vessels and other typical equipment used in petrochemical processing.

FIREBRICK

★

KAO-HB

HIGH BURNED SUPER DUTY FIREBRICK

Fusion point 3220 F. This brick offers an excellent balance of properties to assure superior service. It provides approximately 5% more alumina content and lower total impurities than competitive brick. It has excellent spalling resistance.

KAO 60

60% ALUMINA FIREBRICK

Fusion point 3250 F. Provides higher hot load strength than any competitive brick. Spalling loss is only 1%

KAO 70

70% ALUMINA FIREBRICK

Very low total impurities provide long life. Spall loss of only 2%.

RAMMING MIXES

★

MULRAM E

Use limit 3200 F. Alumina content—80%. This new ramming mix with extremely low permeability provides exceptional resistance to slag or molten metal penetration. High strength provides good erosion resistance.

MULRAM EF

Use limit 3100 F. Alumina content—80%. Similar to Mulram E but supplied in finer grain.

MULRAM CB

Use limit 3000 F. Alumina content —78%. A new chemically bonded dry ramming mix that provides greater strength at low temperatures, high modulus of rupture and excellent resistance to abrasion, slag and scale.

FOR COMPLETE PROPERTIES SHEETS and additional information on these new B&W Refractories products, write to The Babcock & Wilcox Company, Refractories Division, 161 East 42nd Street, New York 17, N. Y.

B&W

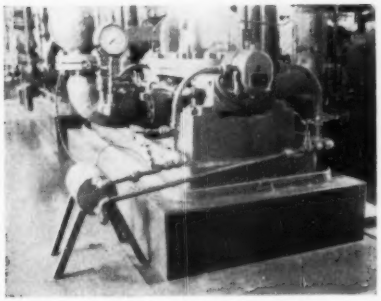
R 657 C

THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

How To Do It . . .



desired to take a 24-hour sample, the sample jar can be set at the outlet and the bleeder valve just cracked sufficiently to allow a few drops to come out at a time.

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Handling costs compel Gulf Publishing Company to make a charge of 10 cents per page (minimum 25 cents) for all TEAR SHEETS ordered. Such tear sheets will be sent, when available, if cash (or company requisitions) is sent with the order.

Small, individual orders for REPRINTS of articles will carry a 50-cent charge per copy WHEN AVAILABLE. Cash (or company requisitions) must also accompany these orders. The $1. price on some of our larger reprints will, of course, continue to apply.

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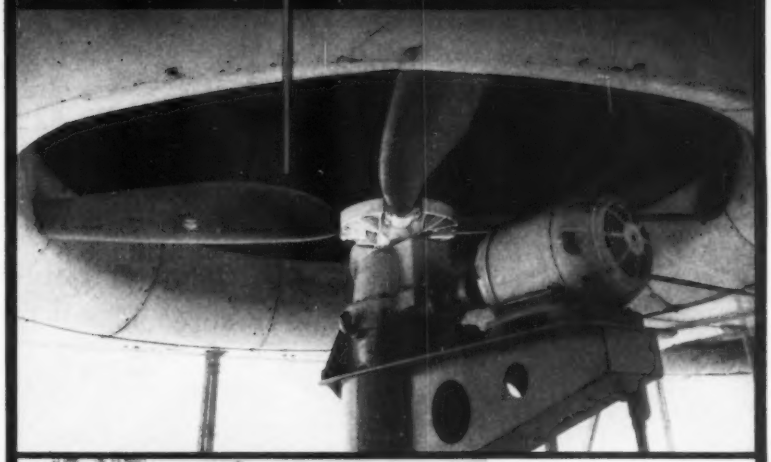
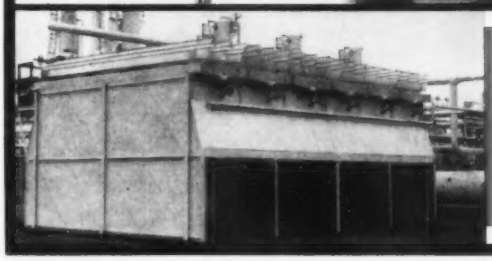
HARTZELL Hollow Glass PLASTIC FAN BLADE





Hartzell Glass Plastic blades are being used in this forced draft heat exchanger operation at El Paso Natural Gas Company's Jal, New Mexico Plant #4. They are 10 feet in diameter and were installed December 22, 1958.

Provides More Efficient, Less Costly Installation, Cooling, Maintenance

• Lightweight (¼ that of standard plastic blade) yet unusually strong. This saves wear and maintenance on bearings, gears, shafts, support members . . . power consumption because it takes less horsepower to move large volumes of air. • Superior resistance to acids, corrosive material, abrasive and impingement effects. • Economical in forced and induced draft, wet and dry applications . . . cooling towers and heat exchangers. • Blades dynamically balanced to hub for quick easy installation and replacement in any Hartzell steel hub. • Design puts fan noise at a minimum. • No painting or finishing—color is in raw material. • Four and six blade assemblies.

Get All The Profit-Facts.
Write direct or call your nearby Hartzell Representative.

HARTZELL
PROPELLER FAN CO.
Div. of Castle Hills Corp. Piqua, Ohio
Engineering Offices in Principal Cities

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Who's Building...

Fish Files $74.5 Million Petrochemical Plan In Argentina

Complex is to be built at San Lorenzo, deep-water port on the Rio Parana. Plant will produce about 45,000 tons per year of synthetic rubber

Fish International Corp. and Associates, Continental Oil Co., Cities Service Co., United States Rubber Co., and Witco Chemical Co., filed on Aug. 22, 1960 with the Argentine Ministry of Economics its plan to set up a major petrochemical complex in Argentina. This filing was in accordance with the terms and conditions of Decree 2154 issued to Fish by the Argentine government on Feb. 25, 1960. The total estimated cost of the installation is $74,500,000.

The complex is to be built at San Lorenzo, a deep-water port on the Rio Parana. Yacimientos Petroliferos Fiscales (YPF) has extensive refining facilities at San Lorenzo, which is also the terminus of the products line recently completed from the Campo Duran fields in the north. The Campo Duran Liquid line, engineered and built by the Fish companies, can deliver up to 55,000 bpd of butane, propane, natural gasoline, and other finished products. Fuel for the complex will be delivered from the Campo Duran natural gas pipeline, a 1200-mile network of gathering system and main line from the Campo Duran and Madrejones fields in Northern Argentina to Buenos Aires.

The proposal is a result of nearly 24 months of study and negotiation with Argentine authorities. In 1958, Argentina established a program to attract foreign investment as part of a general economic reorganization fostered by Arturo Frondizi, Argentine president.

PASA, an Argentine corporation, was formed earlier this year by the associates for the express purpose of owning and operating the major petrochemical complex. The initial installation will incorporate the basic building blocks of benzene chemistry and rubber chemistry, with provisions for the addition of other units for processing by-product raw materials as they become available.

Ray C. Fish, chairman of Fish International, said, "we are ready to begin construction immediately upon acceptance by the Argentine government. Our surveys and engineering to date conclusively show that Argentina needs the products which this complex can produce and can take advantage of the basic raw materials then available for further development." Fish added that construction on all units will proceed simultaneously when approval is granted. Completion is expected within 36 months. First units would be on stream within 18 months. Approximately 700 employes will be required in the operation of the installation.

The benzene phase of the complex will make available all the present benzene requirements of Argentina (presently being imported) and also produce sufficient volume for the production of styrene required in synthetic rubber manufacture and for other chemical uses.

The rubber phase of the complex will substantially produce all of the types of synthetic rubbers required for the rubber industry of Argentina. At the present time Argentina is manufacturing rubber goods entirely from imported rubbers, principally natural rubber with only a limited amount of synthetic rubber.

The rubber requirements of Argentina in 1960 are estimated at 38,000 metric tons and are expected to reach 75,000 metric tons in 1965. The facilities as planned will be flexible, whereby the types of synthetic rubbers that can be used by industry in Argentina can be economically varied to meet market demand.

The products which will be produced by the complex will total approximately 45,000 tons per year of synthetic rubbers, 11,500 tons per year of carbon black, and 7,000 tons per year of styrene surplus to the manufacture of rubber. In addition, the complex will produce 1290 bpd of aviation alkylate and approximately 839 bpd of benzene.

The ultimate installation will include addition of other processing units to further process the by-product raw materials produced initially, and will provide a base to permit further expansion for producing finished products of polystyrene, ethylene, propylene, dodecylbenzene, sodium sulfonate, plasticizers, caprolactam ammonium sulfate and other petrochemical products.

A complete line of integral HP motors: dripproof protected—totally enclosed—and explosion proof

ELLIOTT C-W MOTORS

conservatively designed, ruggedly built, highest quality throughout

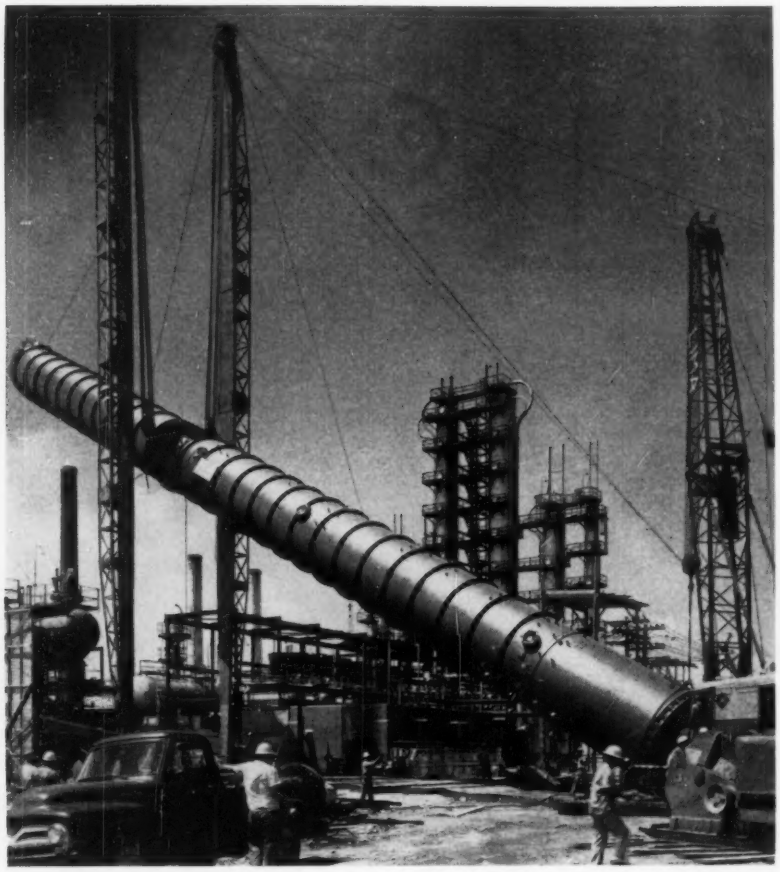
The extra service users enjoy from Elliott C-W motors is due to the conservative design, precision manufacture and high-quality materials of these machines. For most applications, the dripproof-protected type gives dependable service. Where conditions are more severe the totally-enclosed or explosion-proof construction may be required. Recently added to the line are the EPA-SEAL epoxy insulated C-W motors for service where moisture or corrosive atmospheres demand superior insulation.

Vacuum-pressure process thoroughly impregnates coils with epoxy resin.

ELLIOTT Company
Crocker-Wheeler Plant
Jeannette, Penna.

WO-2

Building . . .



Heavy Lift Devised to Erect Debutanizer Tower

One of the heaviest single lifts made in the oil industry has been completed at Gulf Oil Co.'s Port Arthur, Texas, refinery. A huge deisobutanizer tower was eased into place after one of the most complex rigging jobs in the history of the refinery. The tower was erected between two operating units with a few feet of clearance on either side.

Fabricated by the American Bridge Division of U.S. Steel at Orange, Texas, the tower was moved by rail to the refinery. Five flat cars were used and the 18-mile trip was made only during the daylight hours over a period of two and a half days. Measuring 196 feet 4 inches in length, it is 20 feet across the base and weighs 195 tons.

Greece plans to erect a sulphuric acid plant at Ptolemais. Chemical Construction Corp. will furnish the design, engineering, equipment and supervision of construction of the unit, which will be built for the Greek Ministries of Industry and Coordination.

Petroleum Chemicals, Inc., is expanding its Lake Charles, La., ethylene plant by 50 percent. The expansion of the plant, which has been on stream about a year, will raise its annual capacity to 300 million pounds. The Lummus Co. is engineering the project.

Gulf Oil Corp. is planning a Scandinavian refinery in Denmark. Gulf Oil is presently negotiating for a site near Skelskor on the West Coast of Zealand, near the Tidewater Oil refinery construction about 62 miles from Copenhagen. The unit will be built for a capacity of 80,000 bpd.

Standard Oil Co. (Indiana) will begin construction on a new 37,000-bpd crude plant at its refinery west of Casper, Wyo., next spring. The unit, which is set for completion in September 1961, will enable the company to discharge obsolete facilities, such as existing crude stills, a thermal cracking unit, some tankage and coke stills.

American Oil Co. is planning to build what may be the world's largest alkylation unit at the company's Texas City refinery. Fluor Corp., Ltd., has been awarded the construction contract for the unit, which will produce high octane for the company's unleaded gas. The facility is a major part of the extensive modernization program at the Texas City installation.

Shell Oil Co. is scheduling an expansion of liquid recovery facilities at its Provident City, Texas, gas plant. The new additions will increase the production of propane to 33,000 gallons per day from its present 21,000-gallon rate. Natural gasoline production will be increased about 5,000 gallons per day. Construction is expected to begin in October, with completion scheduled during the first part of 1961.

U.S. Industrial Chemicals Co. has completed expansion of its polyethylene plant at Houston, Texas. The expansion brings U.S.I.'s total production capacity of petrothene low and medium-density polyethylene resins to 300 million pounds per year. The plant had an initial annual capacity of 25 million pounds. This was doubled in 1956 and redoubled in 1957 to a capacity of 100 million pounds per year. In 1959, production was raised to 75 million pounds annually. The present expansion brings the capacity to 200 million pounds.

Cities Service Refining Corp. has awarded a contract to Badger Manufacturing Co. for the engineering, procurement and construction of a Udex aromatics extraction unit and orthoxylene recovery and purification facilities at its Lake Charles, La., plant. The plant will produce 120 million pounds of orthoxylene yearly.

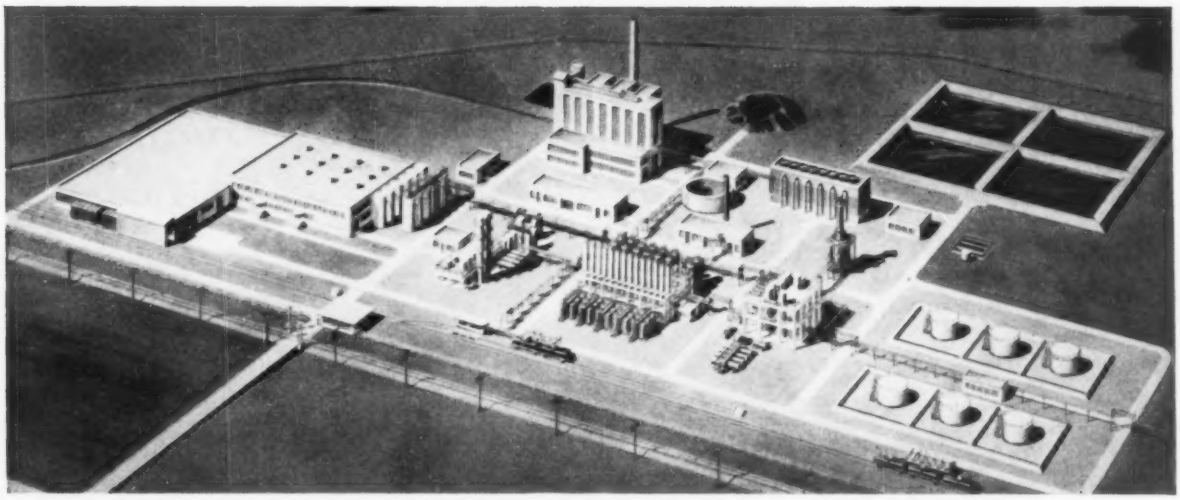
El Paso France-Afrique, French subsidiary of El Paso Natural Gas Products Co. and Compagnie Francaise de Raffinage of France, will build a $17-million petrochemical plant near Le Harve, France, to produce polyethylene resins used in making plastics. The facility will

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

INDIA'S FIRST SYNTHETIC RUBBER PLANT SET FOR SYNTHETICS AND CHEMICALS, LTD.

Lummus to Design, Engineer and Construct 30,000 Ton Per Year Plant Near Bareilly, India



The Lummus Company has been awarded the contract to design, engineer and construct a 30,000 ton per year synthetic rubber plant near Bareilly, Uttar Pradesh, India for Synthetics and Chemicals, Ltd. This firm was recently formed by The Firestone Tire & Rubber Company in association with the banking and industrial firm of Kilachand Devchand and Company Private, Ltd. of Bombay.

The 30 million dollar project will include plants for the production of butadiene and styrene, the principal raw materials, as well as a copolymer plant to manufacture the final product, synthetic rubber. In addition, Lummus will construct all the plant utilities and offsites. Although Lummus will design the plant for a capacity of 30,000 tons or more per year, the initial annual production will be 20,000 tons. Technical divisions of The Firestone Tire & Rubber Company are furnishing the basic engineering and know-how for the butadiene, styrene and copolymer units.

The plant site has been established in the heart of the sugar cane and alcohol producing area, and the alcohol obtained from the sugar cane will be the source of the butadiene, the principal ingredient of synthetic rubber.

Indian technicians and operating personnel will be trained to run the plant, whose final products will meet standard world-wide industry specifications.

Financing of the project will be assisted by a 27,100,000 Indian rupee (or $5,700,000) loan from the Export-Import Bank of Washington to Synthetics and Chemicals, Ltd. This constitutes the largest foreign currency loan in the bank's history. The remainder of the financing will come from private banks in the United States and the United Kingdom as well as from India.

The project is expected to save India approximately 10 million dollars in foreign exchange annually.

Lummus has over 50 years' experience in the design and construction of more than 850 plants for the process industries throughout the world. Call Lummus on your next project.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, New York, Houston, Washington, D. C., Montreal, London, Paris, The Hague, Madrid; Engineering Development center: Newark, N. J.

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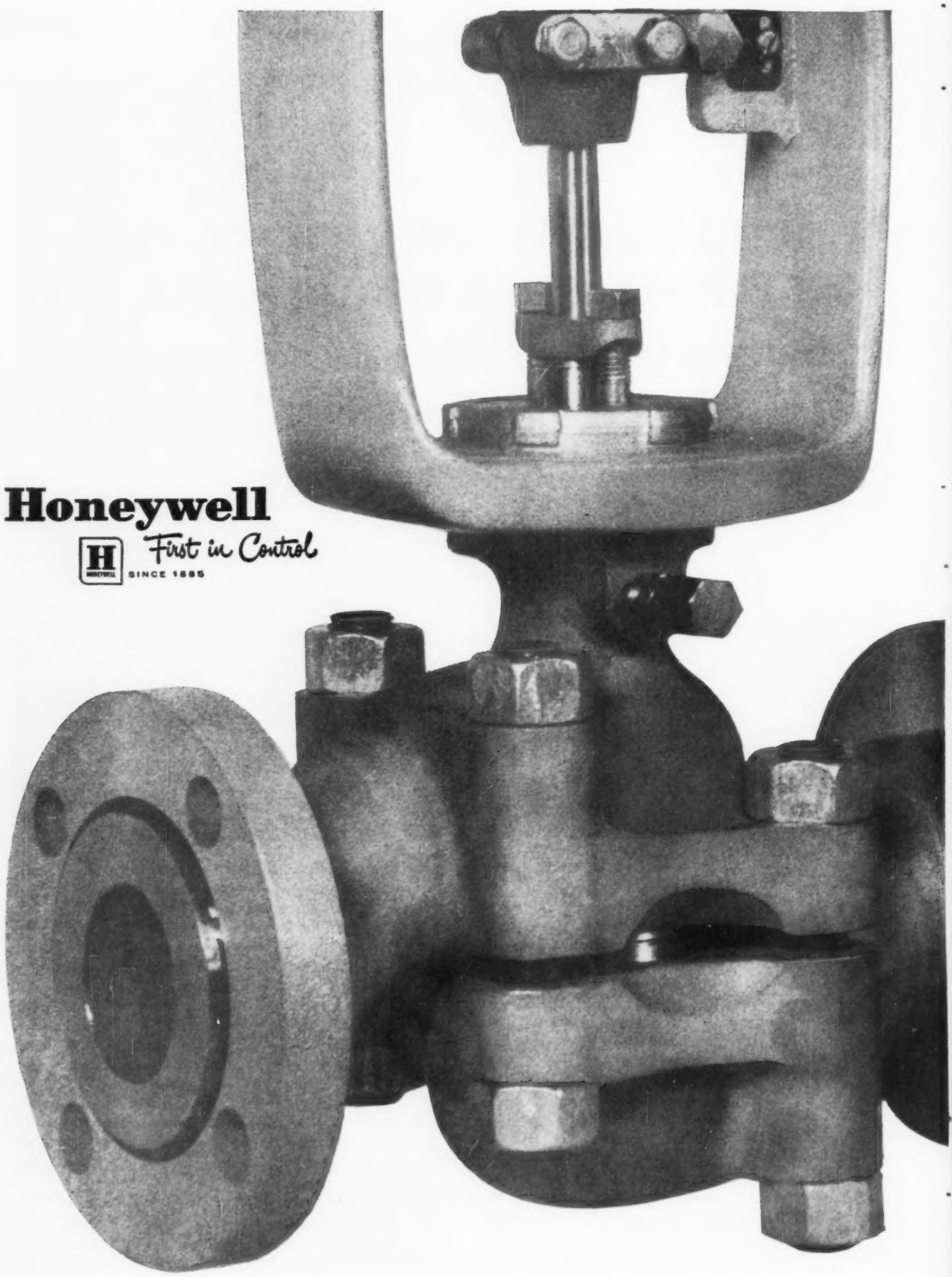
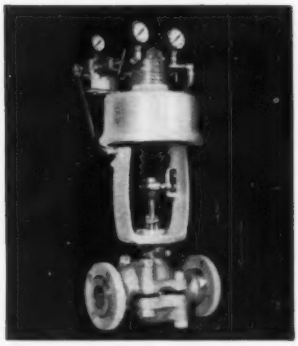
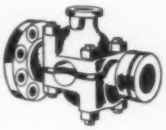

Honeywell
First in Control
SINCE 1885

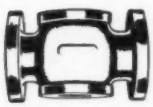


Now, a new split-body valve makes possible a flexible intermix of Honeywell valves and actuators—a combination designed for both economy and perfect matching of valve to application. For example, you can get the split-body valve with cost-cutting, clamped-in seat rings, separable flanges and the new cylinder actuator.



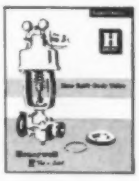
Or perhaps your application calls for the split-body with fixed flanges and the economical diaphragm actuator.

With high temperatures, you'd probably prefer this globe body valve, with either the cylinder or diaphragm actuator.



In any case, the completeness of the Honeywell line lets you select the valve-actuator combination that's exactly right for the job... without pushing a valve beyond its design limits, without paying for more than you need.

Write for Bulletin B-802-1.



75th YEAR PIONEERING THE FUTURE **Minneapolis-Honeywell, Fort Washington, Pa.**

Building . . .

have an initial capacity of 44 million pounds of resins yearly. It will receive its raw materials from Compagnie Francaise's 150,000-bpd Confreville oil refinery near Le Harve. Completion is set for 1963.

Southland Co. is reported to have purchased a site at Black Point, Fla., for the construction of a 15,000-bpd refinery to cost $8 million.

Kokan Chemical Industries Co., Ltd., has completed a Udex unit at its Kawasaki, Japan, plant. Benzene from the 500-bpd Udex facility will be charged to a catalytic condensation unit for production of ethylbenzene. Dehydrogenation and styrene purification units to convert the ethylbenzene to styrene are also planned. Universal Oil Products Co., designer of the Udex unit, also is designing the catalytic condensation unit and the styrene facilities.

Ashland Oil and Refining Co. is building a 32,000-bpd vacuum distillation unit for its Catlettsburg, Ky., refinery. Scheduled for spring 1961 completion, the facility will produce light and heavy gas oil for catalytic cracking charge stock, cylinder stock and asphalt. The unit will replace three smaller vacuum units, Badger Manufacturing Co. is handling design engineering and construction.

Allied Chemical Corp. has begun construction on a multi-million-dollar polyethylene plant at Orange, Texas. The plant will provide an increase of low-molecular-weight polyethylene by about 50 percent.

Jefferson Lake Petrochemicals of Canada, Ltd., plans to build a gas gathering system and processing plant to serve the Calgary, Alta., gas field. The facilities are to be installed next year. Cost of the unit is estimated at $12 million. It is expected to process 150 MMcfd of raw gas.

Samir Oil Co. has started to build a refinery at Mohammedia, near Casablanca, Morocco. Samir is owned equally by Morocco and ENI. The plant is scheduled to go on stream in 1962 and will operate on imported crude until crude produced in Morocco is available.

Avi-Sun Corp. has a multi-million-pound-per-year polypropylene plant planned at New Castle, Del. The plant will have an initial capacity of 75 million pounds per year with provision for expansion to 100 million pounds yearly.

Hercules Powder Co. is undertaking another project in the expansion program at its Contra Costa County, California, plant. Expansion consists of a cracking furnace plus facilities for the synthesis and purification of methanol and for the manufacture of formaldehyde, urea-formaldehyde solutions and allied solid products.

Texaco, Inc., has expanded its Trinidad refinery with a 100,000-bpd crude unit, a 20,000-bpd gas-oil hydrotreater, a 15,000-bpd Unifiner-Platformer and a 280,000-pound-per-hour boiler plant. Construction was handled by Caribbean Bechtel, Ltd.

Shell Chemical Co. has awarded a contract for expansion of its styrene production facilities at Torrance, Calif. The expansion, scheduled for completion early in 1961, will raise the plant's capacity to 210 million pounds per year. The styrene facilities had a rated capacity of 125 million pounds a year in 1955. Completion of the new program will result in a total expansion of nearly 70 percent since the plant has been in private operation.

Columbian Carbon Co. will construct a plant in the Gulf Coast area of Texas for the production of dispersions of carbon black in polyethylene, polypropylene, and other similar resins. The new facility is expected to begin operation in the

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973 JOBS
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During our brief history we have seen air cooling evolve from an experiment to an exact science. First we cooled water, then gas. As we gained experience and know-how, we successfully met and overcame the problems involved in the cooling and condensing of light hydrocarbons. Today, SMITHCO is able to apply air cooling to any material that will flow through tubes.
One prominent reason for the wide acceptance of our coolers is the Molecular Bond fin tube. SMITHCO is the only builder of industrial air cooled heat exchangers that provides this unique engineering feature which furnishes an uninterrupted metallic thermal path for flow of heat from the inside of the tube to the outermost edge of the fin.
When cooling problems arise, why not put our nine years of progress to work for you? SMITHCO has the facilities and engineering ability to produce a complete range of air cooled heat exchangers from the simple water cooler to the most complicated process coolers and condensers.
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For more data on advertised products, use Readers' Service Cards, last page.

DU PONT *Petroleum Chemicals* NEWS

Number 104 in a series of bulletins for the Petroleum Industry

SEPTEMBER • OCTOBER 1960

Foam killer finds new uses in gas scrubbing

The primary use of DuPont's OCENOL® anti-foaming agent in the petroleum industry has been as a foam-breaker in the Girbotol process.

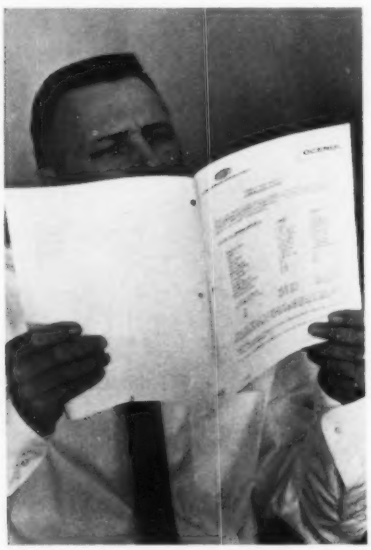
Now OCENOL is finding increasing use in atmospheric and vacuum distillation processes. Full-scale use in several such operations indicates that it is one of the most effective anti-foam agents available for the job.

And it has cost-saving advantages, too. OCENOL carries a low price tag, works effectively in concentrations of 0.1 to 0.3 lb. per 1,000 barrels. The result is that on a performance basis you pay a very low price to break foam with OCENOL.

What OCENOL is

OCENOL is a technical grade of oleyl alcohol rich in cetyl and unsaturated C_{18} alcohols. It is available in two forms: OCENOL and OCENOL P. OCENOL P contains a lower proportion of unsaturates than OCENOL. In some applications, the products can be used interchangeably.

OCENOL may be the answer to your foaming problem. Write direct to Wilmington for technical data, or contact your DuPont Petroleum Chemicals representative.



How to stop paying for sludge in distillate and residual fuels

One shovelful of sludge. Looks like so little. *Yet you pay for it three times* in the marketing of a distillate and residual fuel.

You pay for downtime and labor when storage tanks must be desludged. You pay for lost product. You pay for excessive filter and strainer replacement, or for handling complaints from customers who have these problems.

This is money you do not have to spend. Care in handling, in the blending of fuels and in the use of proper additives will save you this money. To overcome sludge, add DuPont Fuel Oil Additive No. 2 to your product. For every 1,000 barrels of residual or diesel fuel, you need only a small amount of DuPont FOA-2 — usually 5 to 15 pounds. This stabilizes, solubilizes, disperses and keeps insoluble particles in suspension so they won't form residue.

You get just as much burnable fuel *out* of the storage tank as you put *in*, with nothing lost to sludge.

Customer Benefits. In diesel fuels, FOA-2 eliminates or greatly reduces filter plugging and injector sticking. One user reported that filter life doubled on heavy roadbuilding equipment with subsequent savings in labor, downtime and filter replacement.

Being nonmetallic, FOA-2 burns right along with the fuel, leaves no ash or other deposit. Does not contribute to sparking problems.

In residual fuels, FOA-2 prevents or reduces tank sludging, burner fouling, and strainer and heat exchanger clogging.

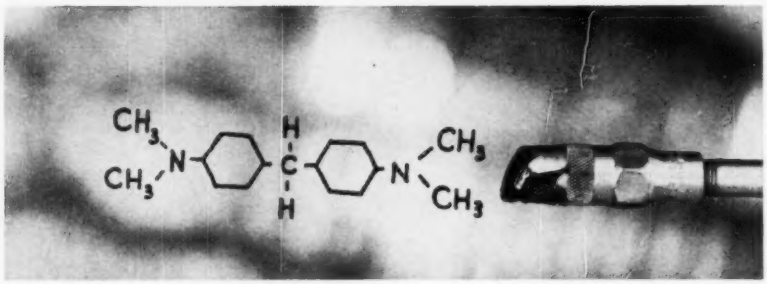
The Science of Sludge. The petroleum industry has used DuPont FOA-2 in millions of barrels of diesel and residual fuel since its introduction nine years ago. At DuPont, sludge formation, prevention and removal has become a science, and our experience is available to help you improve the flow and burning properties of your product. Call or write for our bulletin on FOA-2, or for consultation on sludge prevention.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DUPONT *Petroleum Chemicals* NEWS

New way to stabilize your grease and oils



Oxidation is, of course, one of the bitterest enemies of the grease and oil you produce.

The problem looks simple on the surface: use an antioxidant.

But what complicates it is *cost*. Profit margins don't permit you to pay so much money for additives that your product ends up with a price tag that's out of line with competition.

Answer from Du Pont

Now there's a way out of this problem. Currently available is a Du Pont antioxidant that effectively stabilizes greases and lubricating oils, protects them from oxidation, *yet is used in small concentrations.*

Called ORTHOLEUM 304, this product is an antioxidant with one of those jawbreaking chemical names you like to roll around on your tongue: 4, 4' tetramethyldiamino-diphenylmethane.

ORTHOLEUM 304 is a light grayish granular solid, with excellent storage stability. Melting point: 190°F. Bulk density: approx. 5 lb./gal. Supplied in 47-gallon fiber drums containing 200 pounds net.

Samples available

If you want smooth, uniform texture, even when your grease or oil has been stored for a time, look into the economy of ORTHOLEUM 304. The broad uses of this antioxidant are illustrated by 17 references contained in our literature. Ask your Du Pont Petroleum Chemicals Division representative for details and a sample, or write direct to Wilmington, Delaware.

CHICAGO DISTRICT MANAGER

JAMES M. MOSTYN is manager of the Chicago District, Du Pont Petroleum Chemicals Division.

Prior to joining Du Pont in 1948, Jim worked in the petroleum additives field for several years. During his service with the Corps of Engineers of the U. S. Army, he was assigned to various duties in North Africa, Italy, and France, for which he received four battle stars and a Bronze Star.

His first assignment with Du Pont was in the Central Region Laboratory of the Petroleum Chemicals Division. By 1958 he had become manager of the Chicago District office.

His work with Du Pont's Petroleum Chemicals Division has covered laboratory, safety, construction and sales, which explains why Jim is especially qualified to give technical help to users of Du Pont tetraethyl lead and our other petroleum additives.

A native son, Jim lives today in the same town in which he was born, Summit, Illinois. At home his life centers around (a) his wife, Lorraine, three daughters and two sons, (b) his golf clubs and (c) his fine pipe collection. Next time you're passing by 8 South Michigan Avenue in Chicago, stop in for a chat. You choose the subject . . . petroleum, putts, pipes or potpourri.

Heard about Du Pont's new "hush hush" dye?

Du Pont's new Oil Color IA has been created to identify products which, for various reasons, you choose not to give a distinctive color.

It's an undercover dye, an identifying agent (IA). Though it adds no appreciable color to your product, you can easily detect its presence by simple tests.

For example, a few drops of gasoline or kerosine containing 0.5 to 1.5 grams of Du Pont Oil Color IA per 100 gallons will immediately produce a blue spot on a paper towel.

Smaller concentrations – as little as 0.03 grams per 100 gallons – can be detected by shaking the gasoline with a little methanol and acid water and observing the color of the methanol layer.

Purpose? You can solve many special problems with this unusual dye, including: coding products to determine source, brand or grade; identifying gasolines for tax purposes; controlling proper use of products; deterring pilferage.

Ask your Petroleum Chemicals representative for more information.

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Du Pont Lead Antiknock Compounds and other Petroleum Additives

OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

A-17012

Printed in U.S.A.

Building . . .

fourth quarter of 1960. It is designed for an annual operating capacity of 8 million pounds and will supplement Columbian's existing production in Tacony, Pa.

Societe Anonyme Reichhold Beckacite, France, an affiliate of Reichhold Chemicals, Inc., White Plains, N.Y., will build a maleic anhydride plant at Niort, Deux-Sevres, France. Scientific Design Co., Inc., will design the plant and grant a license for the use of the SD maleic anhydride process and the special catalyst required. Engineering services, as well as complete equipment and construction of the plant will be furnished by Societe Francaise des Services Techniques S.a.r.l., Paris, France, a member of the SD Group.

Thailand will build a catalytic cracking unit on the Chao Phraya River outside Bangkok. The project has been licensed by Houdry Process Corp. to the Defense Energy Department of the government of Thailand. Completion date is late 1961.

Sociedade Anonima Concessionaria da Refinagao de Petroleos is planning to expand the catalytic cracking and related facilities at its refinery outside Lisbon, Portugal. The original plant has a capacity of 24,000 bpd. Engineering for the expansion will be handled by Hydrocarbon Research, Inc., New York. Completion is set for early 1961.

El Paso Natural Gas Products Co. has begun construction on an addition to its Odessa, Texas, styrene plant. The plant, now operating at a capacity of 60 million pounds per year, will be increased to 80 million pounds capacity. Universal Oil Co.'s Alkar process will be used in the expansion program.

CATC Group has completed a $1,300,000-adsorption-type gasoline plant at Grand Chenier, La. Continental Oil Co. is operator for the CATC Group which also includes The Atlantic Refining Co., Tidewater Oil Co. and Cities Service Co. The plant has an initial capacity of 175 MMcfd, which is expected to be expanded at a later date.

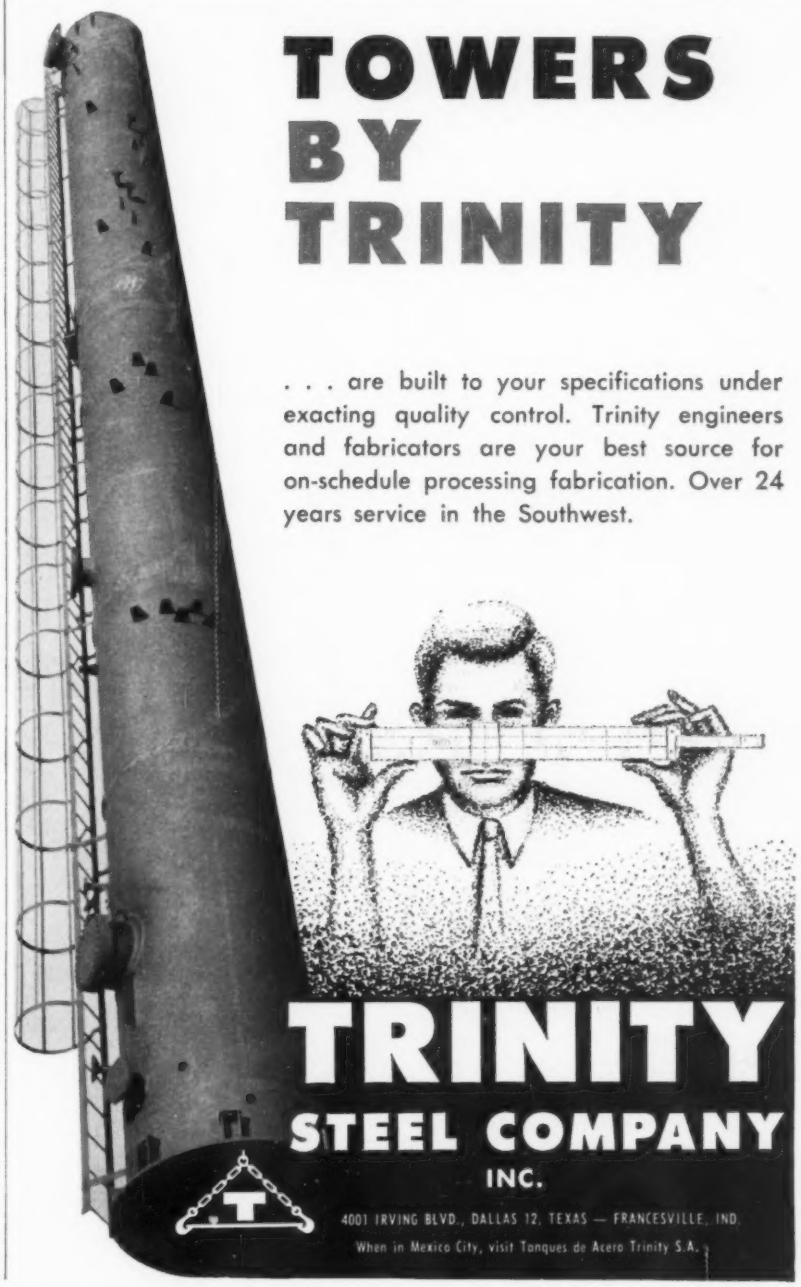
Naph-Sol Refining Co., Muskegon, Mich., is expanding with the addition of a 5,000-bpd Unifining unit. Completion is scheduled for 1961.

Phillips Petroleum Co. will construct and operate a joint-interest natural gasoline plant, known as Vermilion Plant, five miles southeast of Abbeville, La. Owners of the plant will include Phillips, Tidewater Oil Co., Pan American Petroleum Corp., Robert A. Mosbacher, Jewell M. McDonald, Winston L. Stokes, Thomas A. Durham, and Charles L. Beck. The unit will process approximately 45 MMcfd of natural gas produced from the North Erath field. Both high and low-pressure gas gathering systems will serve the plant. Completion is expected in December of this year. Products of the plant will consist of propane, butane, and LPG mixtures, and natural gasoline.

Mobil Chemical Co. plans to produce benzene in a multi-million-dollar plant to be constructed at Beaumont, Texas. Initially the new facility will yield more than 30 million gallons of benzene annually. Toluene will also be produced. The Company estimates that production from the new plant will begin in about 16 months.

Shell Oil Co.'s 85,000-bpd refinery at Godorf, near Cologne, Germany, which is expected to be the model for its future refineries built in other parts of the world, has gone on stream.

N. V. Chemische Industrie Aku-Goodrich (Ciago) is expanding its synthetic-rubber producing facilities in the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Building . . .

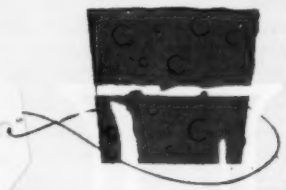
Netherlands. Ciago is a jointly-owned company of B. F. Goodrich Chemical Co. and Algemene Kunstzijde Unie N.V. of Holland. The expansion is expected to be completed by early 1961.

Siberia is reported to have a refinery of unknown size on stream at Irkutsk, in Eastern Siberia. The plant is said to be running Baskirian crude transported by railway tank car.

Southern Nitrogen Co., Inc., Savannah, Ga., is planning to raise its urea capacity from 10,000 to 16,000 tons per year. Expansion completion is set for January 1, 1961. Nitric acid facilities will be increased from 100,000 to 130,000 tons per year by October 1961.

Skelly Oil Co. will build a gasoline plant near Minneola, Kan., to process gas from Skelly wells in the Meade County field. The plant will recover 15,000 gallons of products per day.

Monarch Oil Corp. is planning to modernize the 5,000-bpd refinery at Signal Hill, Calif., owned by Olympic Refining Co. Facilities will be installed to produce diesel fuel, solvents, kerosine, lubricating-oil stocks and asphalt.



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El Paso Natural Gas Co. is planning to build gas facilities in Ector County, Texas, to cost about $3,930,000. The new installations are expected to furnish the firm's Goldsmith compressor station a net increase of about 58 MMcfd.

Shell Oil Co. has begun preliminary work on a 20,000-bpd refinery on Pulau Bukom island near Singapore. Completion is slated within two years.

Dow Chemical Co. is joining forces with Maruzen Oil Co. to build a 10,000-ton-per-year phenol plant at Matsuyama, Japan. The unit is expected to cost $44 million. Mitsui Petrochemical Industries, Ltd., is the only phenol producer in Japan.

Phillips Petroleum Co. is proposing to build a synthetic rubber plant near Gauhati, Assam, India. Estimated cost of the project would be about $24 million. An offer was made the Indian government by Phillips' Special Products Division.

Linde Co. will further expand its oxygen-producing facilities this year with the intallation of a new on-site plant in Pueblo, Colo. The plant will supply more than 200 MMcf of oxygen per month to The Colorado Fuel and Iron Corp. Pueblo plant.

Gulf Oil Corp. has awarded a contract to some French companies and Procon, Inc., to construct a 10,000-bpd refinery in the Philippines.

Ceylon proposes construction of a refinery. The country has already been offered Rumanian aid for a state plant, which it now favors over the joint bid of Standard Vacuum Oil Co., Caltex, British Petroleum Co. and Shell Oil Co.

Monsanto Chemical Co. will build a multi-million-dollar installation to produce phthalic anhydride and phthalate ester plasticizers at its Gloucester County, New Jersey, site. Completion is set for early 1962.

Diamond Alkali Co. is to build an acetylene unit at its Deer Park plant near Houston, Texas. A production of 40 to 60 tons per day will be used to make vinyl chloride monomer. Completion will be in November 1961.

Imperial Oil Co., Ltd., will build a benzene plant at Sarnia, Ont., to cost $5 million. The unit, which will have an estimated capacity of 30 million gallons per year, is scheduled for completion by the fall of 1961.

Esso Petroleum Co., Ltd., is planning to build a butyl rubber plant at its Fawley, England, refinery. The 30,000-ton-per-year plant is set for completion in 1962 or 1963 and will cost about $13 million.

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the American Institute of Chemical Engineers announces...

A.I.Ch.E. PETROCHEMICAL AND REFINING EXPOSITION!

For some time, the A.I.Ch.E. has been aware of an increasing demand for a petrochemical and refining exposition... to bring together in one place the seemingly inexhaustible number of new developments and new ideas associated with this dynamic and expansive field... and to put it into its proper focus in the overall chemical and petroleum picture.

NOW— for the first time in history—this show becomes a reality!

THE TIME: FEBRUARY 26—MARCH 1, 1961

THE PLACE: NEW ORLEANS, LOUISIANA

will you be there? This is *one* exposition you should not miss, for it will bring together under one roof some of the most important developments in the field... developments that you, as a chemical or petroleum engineer, should know about in intimate detail.

Sponsored by the American Institute of Chemical Engineers, the first Petrochemical and Refining Exposition will be held in conjunction with a national meeting of the A.I.Ch.E. Exhibits will be at the Municipal Auditorium, and meetings will be held there as well as at the Roosevelt Hotel. Fabled New Orleans is the ideal site for this important show—for 85% of the petrochemical industry and 35% of the refining industry are within a radius of a few hundred miles.

Several hundred exhibitors will display their products and services, with equal space being planned for both petrochemicals and refining. Papers presented at the meeting will be among the most important of the year, and will be released simultaneously to all publications. And for a big "plus," many interesting plant trips in the vicinity are being planned for you to attend.

The tentative program will feature sessions on kinetics, petrochemicals, future of the industry on the Gulf Coast, solids, future processing technology in the petroleum industry, liquid-liquid extraction, education and professionalism and many other important subjects.

PLAN YOUR TRIP TODAY!

Hotel space is certain to be at a premium for this unusual show, so we suggest an early reservation. Contact the American Institute of Chemical Engineers, 25 West 45th Street, New York 36, N. Y. for details and further information.

For complete and up-to-date information on the latest petrochemical developments, you should become a member of the American Institute of Chemical Engineers. Just send in this coupon for full information.

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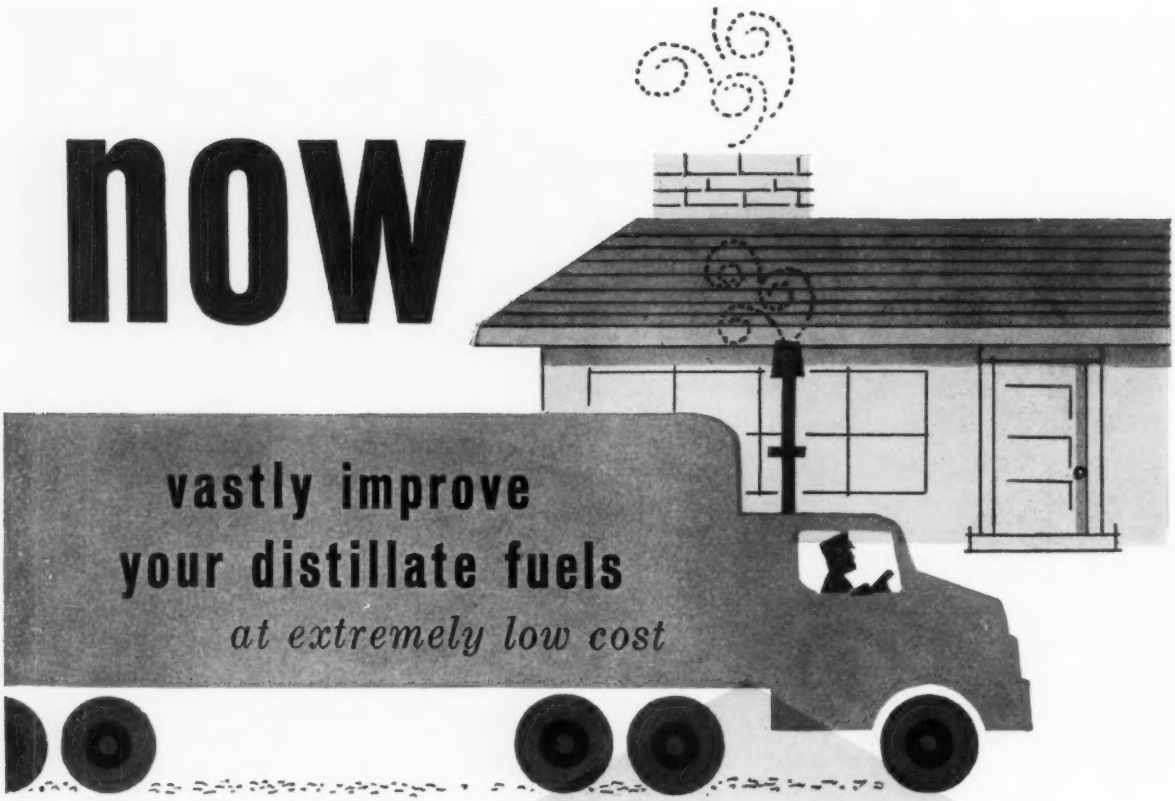

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POLYFLO ™ *inhibitor-dispersants: Made in three formulations. Stabilize against thermal changes, color deterioration, sludge and deposit formation.*

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No one inhibitor or inhibitor-dispersant can fully and effectively protect *every type* of distillate fuel. Each needs its own proper inhibitor selection, which must be determined on the basis of a comprehensive analysis of the fuel to be treated.

In response to this need, UOP offers a unique and highly valuable service that includes determining your precise inhibitor needs, based upon inspection and study of your fuels. From this analysis, we will determine the best inhibitor or most effective inhibitor blend recommended for each type of fuel you market.

Use of the correct inhibitor or blend of inhibitors for a given distillate fuel assures maximum stability at minimum cost. Reduced concentration of inhibitors also minimizes water absorption.

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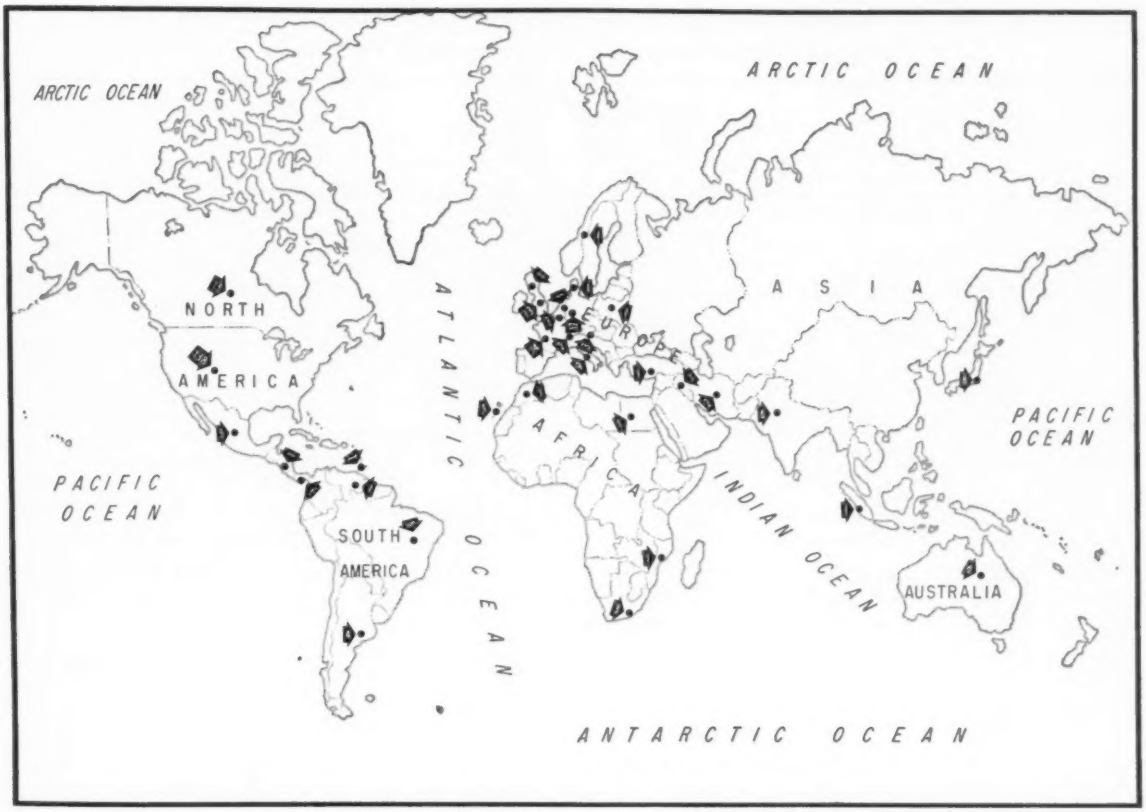
WHERE RESEARCH TODAY MEANS PROGRESS TOMORROW



Projects presently under construction throughout the world by country.

Construction Rises Over Last Year

A survey of two Construction Boxscores, October 1959 and October 1960, shows refiners are picking up construction and planning throughout the world. The following article gives a nutshell rundown on construction, planning and expansion projects on a world-wide basis. The breakdown is further simplified by an accompanying table.

This month's tabulation of Construction Boxscore reveals a slight increase in projects under construction over last year's rundown during this same period. The survey shows 268 items were listed under construction in 1959, while 284 are in the construction status this month.

Planned projects also show an increase over last year. Approximately 140 listings are in the planning stages for this October. Last year a total of 66 was counted. Planning in the United States was listed 20 times in October 1959; this year 39 projects are planned.

Expansion projects for the world numbered about 60 for the 1959 rundown. Approximately 80 refinery, petrochemical or natural gasoline facilities are listed as expanding in 1960.

U.S. Construction

In tabulating the items under all areas of the United States, 120 were under construction in 1959. This year's count numbers 138 projects. The greatest amount of construction activity for the U. S. for both this year and last is shown in the Mid-Continent and Southwest divisions.

Cost Range

Estimated costs for the world-wide tabulation ranged from $50,000 to $95 million during the 1959 period. The estimated $95 million was being spent for a vast petrochemical plant at Brindisi, Italy, by Montecatini Oil Co. In 1960 the lowest estimated cost was $30,000. Montecatini again holds the highest estimated cost for the 1960 tabulation at $95 million for the petrochemical plant in Italy.

This year marks the thirteenth for the Construction Boxscore, which is printed quarterly in the PETROLEUM REFINER.

	WORLD		U.S. PORTION	
	1959	1960	1959	1960
Under Constr....	268	284	120	138
Planning...	66	140	20	39

HPI Construction Boxscore

Hydrocarbon Processing Plants

East

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Air Products	Iselin, N.J.	Liquid Helium			Under Constr				
American Rubber & Chemical	Louisville, Ky.	*Polybutadiene, Polyisoprene	30,000 tons/yr		Engineering	Sept 1961	Phillips	Staff	
Ashland O&R	Buffalo, N.Y.	Naphthalene	50,000,000 gal/yr		Under Constr		UOP		
		Benzene	10,000,000 gal/yr		Engineering	May 1961	UOP	Staff	Staff
	Catlettsburg, Ky.	*Benzene	15 MM gal/yr		Under Constr	Early 1961	UOP	Badger Mfg	Badger Mfg
		*Catalytic Reformer	12,000 bbls	$3,000,000	Engineering	May 1961		Blaw-Knox	Blaw-Knox
		*Vacuum Crude Distillation	32,000 bbls		Engineering	Early 1961		Badger Mfg	BadgerMfg
AviSun	New Castle, Del.	Polypropylene Resin	100,000,000 lbs/yr	$30,000,000	Engineering	May 1961	Staff	Bechtel	Bechtel
Cary Chemicals	Flemington, N.J.	Polyvinyl Chloride, Polymers			Under Constr	1960	SD	SD	SD
Du Pont	Belle, W. Va.	Methyl Methacrylate			Planning	1961			
	Florence, S.C.	Polyester Film		$20,000,000	Under Constr	1961			
	Memphis	Acrylonitrile			Under Constr	1961			
Foster Grant	Leominster, Mass.	Plastic Polymers, Copolymers, Styrene Monomer, Molded Plastics		$4,000,000	Planning				
Frontier Refining	Jacksonville, Fla.	Refinery	10,000 bbls		Planning				
Goodyear	Niagara Falls, N.Y.	*Exp. Polyvinyl Choride			Engineering	July 1961			
Grace Chemical Div., W.R. Grace	Memphis	Exp. Ammonia	450 tons		Under Constr	Mid 1961	Chemico	Chemico	Chemico
Gulf Oil	Philadelphia	Oxo Alcohols	35,000,000 lbs/yr		Under Constr	Dec 1960	Gulf Oil	Badger Mfg/Gulf	Badger Mfg/Gulf
	Charleston, S.C.	Exp. Ethylene			Under Constr	1960			
Hatco Chemical	Fonds, N.J.	*Phthalic Anhydride	22,000,000 lbs/yr	$2,500,000	Under Constr	1960	Sherwin/Williams	Badger Mfg	Badger Mfg
Hercules Powder	Burlington, N.J.	Dimethyl Terphthalate	36,000,000 lbs/yr		Under Constr	1960			
Hess Trading & Transport	Sewaren, N.J.	Exp. Refinery	35,000 bbls		Planning				
		Udex			Planning				
		Catalytic Cracking			Planning				
Heyden Newport Chemical	Fords, N.J.	Maleic Anhydride	24,000,000 lbs/yr		Under Constr	Early 1961		S D	S D
Kendall Refining	Bradford, Pa.	Crude Revamp	5,000 bbls	$160,000	Complete			Litwin	Staff
Koppers	Follansbee, W. Va.	Desulfurization	60,000,000 lbs/yr		Under Constr	Late 1960		Staff	Staff
	Kobuta, Pa.	Phthalic Anhydride			Under Constr	1960		Foster Wheeler	Foster Wheeler
Novamont	Neal, W. Va.	Isotactic Polypropylene, Other Petrochemicals	22,000,000 lbs/yr		Under Constr	Early 1961	Montecatini	Staff	Staff
Olin Mathieson	Brandenburg, Ky.	Ethylene Oxide			Under Constr	Late 1960	Shell Devel	Lummus	Lummus
Pantesote	Passaic, N.J.	Polyvinyl Chloride			Under Constr	1960	SD	SD	SD
Pittsburgh Coke & Chemical	Neville Island, Pa.	Maleic Anhydride	20,000,000 lbs/yr		Planning	Early 1961		SD	SD
Quaker State Oil Refining	Farmers Valley, Pa.	Exp. Refinery		$400,000	Complete				
Reichhold Chemicals	Tuscaloosa, Ala.	Formaldehyde	35,000,000 lbs/yr		Planning		Staff	Staff	Staff
		Phenol		$2,500,000	Under Constr				
Shell Oil	Little Creek, Miss.	Natural Gas Liquids	5 MMcf		Planning				
Southern Gas Board	Reading, Pa.	*Catalytic Oil Gasification	7 MMcf		Complete		Power-Gas	Power-Gas	Power-Gas
Standard of Indiana	Whiting, Ind.	Vapor Recovery			Complete			McKee	McKee
		Exp. Cat Cracker	10,000 bbls		Complete			Kellogg	Staff
		Alkylation	11,400 bbls		Under Constr	1961		Bechtel	Bechtel
		*CO Boiler			Under Constr	1961		Babcock & Wilcox	Staff
Stauffer Chemical	Delaware City, Del.	Carbon Bisulfide			Under Constr	Nov 1960		Staff	
Sun Oil	McComb, Miss.	Natural Gasoline	10 MMcf	$1,400,000	Under Constr	1960		Pona	Pona
SunOlin Chemical	North Claymont, Del.	Exp. Ethylene, Ethylene Oxide, Ethylene Glycol	200,000 lbs/yr	$15,000,000	Engineering				
Tennessee Corp.	East Tampa, Fla.	Ammonia	100,000 tons/yr	$13,000,000	Planning	Early 1962			
Texaco	Westfield, N.J.	*Cumene	70,000,000 lbs/yr		Complete		UOP	Kellogg	Kellogg
United Refining	Warren, Pa.	H_2SO_4 Alkylation	1,100 bbls	$1,300,000	Under Constr	Late 1960		Kellogg	Kellogg

Mid-Continent

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Allied Chemical	South Point, Ohio	Exp. Methanol	50%						
		Exp. Formaldehyde	35%						
Antelop Gas Products	Kimball, Neb.	*Natural Gasoline	10 MMcf		Under Constr	1960		Olsen	Olsen
Archer-Daniels-Midland	Peoria, Ill.	Chemical Derivatives			Engineering	1962		Girdler	
Ashland O & R	Canton, Ohio	Gas Revamp			Complete			Procon	Procon
Aurora Gasoline	Detroit	Naphtha Unifining	8,000 bbls		Complete		UOP	UOP	Treco
Borden Chemical	Illiopolis, Ill.	Polyvinyl Chloride	40,000,000 lbs/yr	$4,000,000	Planning				
British American	Marlow, Okla.	Natural Gasoline	50 MMcf		Complete			Olsen	Olsen
Champlin Oil & Refining	Enid, Okla.	Exp. Cat Cracker	20,000 bbls		Under Constr	1960	Kellogg	Staff/Kellogg	Staff
		Exp. Alkylation	2,000 bbls		Under Constr	1960	Kellogg	Staff/Kellogg	Staff
		Delayed Coker	5,000 bbls		Engineering	1961		Fluor	
Continental Oil	Ponca City, Oklahoma	Cyclohexane	20,000,000 gal/yr	$1,000,000	Under Constr	1960			Procon
Cooperative Farm Chemicals	Lawrence, Kan.	Ammonia	100 tons	$5,400,000	Under Constr	1960		Chemico	Chemico
		Urea	30 tons						
Dow Chemical	Midland, Mich.	Exp. Styrene Monomer			Under Constr	Late 1960			
		*Phenol Distillation		$650,000	Under Constr	Late 1960		Badger Mfg	Badger Mfg

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
DX Sunray	Tulsa, Okla.	*Feed Splitter, Udex	650 bbls	$1,500,000	Complete		UOP	Treco	Treco
		*Propane Deasphalting	6,000 bbls	$1,000,000	Under Constr	Nov 1960		Foster Wheeler	Foster Wheeler
		*Crude Distillation	85,000 bbls	$6,500,000	Under Constr	Sept 1961		Foster Wheeler	Foster Wheeler
		*Solvent Dewaxing, Deboiling	5,835 bbls	$7,500,000	Complete		Texaco	Foster Wheeler	Foster Wheeler
Goodyear Tire & Rubber	Akron, Ohio	Exp. Extruded Polyvinyl Chloride			Planning				
Great Northern Oil	Pine Bend, Minn.	H_2SO_4 Alkylation	2,200 bbls	$2,500,000	Complete		UOP	Treco	Treco
Gulf Oil	Cleves, Ohio	Distillate Treater	11,000 bbls		Complete		UOP	McKee	McKee
	Toledo, Ohio	Distillate Treater	16,000 bbls		Complete		Petreco	Staff/Kaighin-Hughes	Staff/Kaighin-Hughes
		Crude and FCCU Revamp			Under Constr	1960	Gulf/Kellogg		Kaighin-Hughes/Kellogg
Lion Oil, Division of Monsanto	El Dorado, Ark.	Unifiner-Platformer	5,000 bbls		Complete		UOP	UOP/Procon	Procon
		*API Oil Trap			Under Constr	1960			Procon
Monsanto Chemical	Monsanto, Ill.	Exp. Phenol			Under Constr	Mid 1961			
	El Dorado, Ark.	Urea Distillation			Under Constr			Chemico	Chemico
	St. Louis	Exp. Maleic Anhydride	20,000,000 lbs/yr		Under Constr			SD	SD
National Cooperative Refining	McPherson, Kan.	*Delayed Coker Revamp		$1,200,000	Engineering	Fall 1961		Staff/UOP	
Ohio Oil	Pulaski, Mich.	Natural Gasoline	25 MMcf		Complete				
Phillips Petroleum	E. St. Louis, Ill.	*NH_3 Bulk Storage	30,000 tons		Engineering	Spring 1961		Girdler	Girdler
RJ Oil & Refining	Princeton, Ind.	Unifiner	1,700 bbls		Planning				
		Crude Distillation	5,000 bbls		Under Constr	1960			
		Platformer	1,700 bbls		Planning				
Shell Oil	Wood River, Ill.	Catalytic Reformer & Offsite Facilities	25,000 bbls	$15,000,000	Under Constr	1960		McKee/Parsons	McKee/Parsons
	Healdton, Okla.	Exp. Plant		$315,000	Under Constr			Staff	Hudson
Skelly Oil	Minneola, Kansas	*Gasoline	25 MMcf		Engineering	March 1961		Dresser	Dresser
Solar Nitrogen	Joplin, Mo.	*Ammonia	300 tons		Under Constr	1961		Kellogg	Kellogg
Standard-Indiana	Whiting, Ind.	Vapor Recovery			Under Constr	1960		McKee	McKee
		Exp. Cat Cracker	10,000 bbls		Engineering	1960		Kellogg	Staff
		Alkylation	11,400 bbls		Engineering	1961		Bechtel	Bechtel
	Wood River, Ill.	Polybutene			Under Constr	1960		Procon	Procon
	Neodesha, Kan.	Exp. Crude	7,500 bbls		Under Constr	1960		Staff	Staff
Standard-Ohio	Lima, Ohio	Acrylonitrile			Complete			Badger Mfg	Badger Mfg
		CO Boiler		$1,500,000	Under Constr	Dec 1960	Babcock & Wilcox		
Sun Oil	Toledo	Propane Deasphalting	9,500 bbls	$3,600,000	Under Constr	Spring 1961		Staff/Foster Wheeler	Foster Wheeler
		*Naphthalene	100,000,000 lbs/yr	$8,000,000	Engineering	Late 1961		Staff	Kellogg
Sunray Mid-Continent	Purcell, Okla.	Exp. Natural Gasoline	25 MMcf	$600,000	Under Constr			Staff/Tuloma	
DX Sunray	Tulsa	MEK, Solvent Dewaxing & Deoiling	5,835 bbls	$7,500,000	Under Constr	1960	Texaco	Foster Wheeler	Foster Wheeler
		Benzene Udex	600 bbls	$1,500,000	Under Constr	Oct 1960	UOP	Treco	Treco
		Crude	85,000 bbls		Planning	Summer 1961			
		Propane Deasphalting	6,000 bbls		Under Constr			Foster Wheeler	Foster Wheeler
Union Carbide	Marietta, Ohio	Bisphenol-A	25,000,000 lbs/yr		Under Constr	Early 1961			
	Whiting, Ind.	Low-density Polyethylene	72,000,000 lbs/yr		Under Constr	1960			
U.S. Industrial Chem.	Tuscola, Ill.	*Polyethylene Melt Homogenizing	37,500,000 lbs/yr		Under Constr	Late 1960		Kellogg	Kellogg
Vickers	Potwin, Kan.	Water Disposal		$230,000	Under Constr	1960		Wilson	McGee & Lewis
Warren Petroleum	Fashing, Field, Okla.	Gas Processing	75,000 gals	$2,500,000	Under Constr	1960		Delta Eng	Delta Eng
		Sulfur	50 tons		Under Constr	1960		Graff Eng	Delta Eng
	Mocane, Okla.	*Exp. Gasoline	to 75 MMcf		Engineering	March 1961		Dresser	Dresser
Western Petrochemicals	Chanute, Kan.	Waste Disposal			Engineering	1960		Litwin	Litwin
		Vacuum Distillation	500 bbls		Engineering	1960		Litwin	Litwin
		Propane Deasphalting	350 bbls		Engineering	1960		Litwin	Litwin

Southwest

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Allied Chemical	Orange, Texas	Polyethylene Glycol			Under Constr				
Aluminum Co. of America	Point Comfort, Texas	*Exp. Natural Gasoline	150 MMcf		Engineering	Feb 1961		Olsen	Olsen
American Oil	Texas City	Crude	150,000 bbls		Engineering	Fall 1961		Kellogg	Kellogg
		Cat Cracker	47,600 bbls		Engineering	Fall 1961		Kellogg	Kellogg
		Alkylation	14,600 bbls		Planning	Fall 1961			
		Butane splitting, Isomerization							
Bay Petroleum	Rockport, Tex.	Exp. Gasoline	75 MMcf		Under Constr	Late 1960		Olsen	Olsen
Carbide & Carbon	Seadrift, Texas	Exp. Ethylene Oxide	to 200,000,000 lbs/yr		Planning			B & R	
		Exp. Polyethylene			Engineering			B & R	
	Texas City	Exp. Ethylene Glycol	65 MMcf		Planning				
Carwin	Houston	*Special Isocyanates	1,000,000 lbs/yr	$1,000,000	Under Constr	Late 1960		Pona Engineers	Mundy Constr
Cities Service	Lake Charles, La.	*Udex Extraction, Orthoxylene Recovery	84,000,000 lbs/yr	$4,500,000	Engineering	1961	UOP	Badger Mfg	Badger Mfg
Coastal Products	Corpus Christi, Texas	Delayed Coking	7,000 bbls	$3,000,000	Under Constr			Treco	Treco
Continental Oil	Lake Charles La.	Straight-Chain Primary Alcohols	50,000,000 lbs/yr		Under Constr	Early 1961			
		Cat Reformer	11,000 bbls	$3,000,000	Complete			Bechtel	Bechtel
		Exp. Natural Gasoline	to 150 MMcf		Under Constr	Jan 1961		Hudson	Hudson
Copolymer Rubber & Chemical	Baton Rouge, La.	Rubber	to 118,000,000 lbs/yr	$3,000,000	Under Constr	Jan 1961		Staff	Staff
		Butadiene	to 55,000 tons/yr	$5,000,000	Engineering	Sept 1961	Dow	Foster Wheeler	Foster Wheeler
Cosden Petroleum	Big Spring, Texas	Exp. Styrene	to 60,000,000 lbs/yr		Under Constr	Dec 1960	Staff	Badger Mfg	Badger Mfg
		*Exp. Polystyrene	to 40,000,000 lbs/yr		Under Constr	March 1961	Staff	Staff	Staff
		Desulfurization	6 MMcf	$200,000	Under Constr	1960		Graff	Badger Mfg
		Ortho-Xylene	70,000,000 lbs/yr			Early 1961			
CM & M Gas Products	Wise County, Texas	Exp. Gas Processing, Liquid Recovery	150 MMcf	$700,000	Under Constr	1960			
Dow Chemical	Freeport, Texas	Acrylonitrile			Planning				
		Styrene-Butadiene Latexes			Engineering	1961			
		Anhydrous Ammonia			Complete				
		Exp. Ethylene 67%			Engineering	1961			
		Exp. Styrene Monomer			Under Constr				
	Plaquemine, La.	Polyethylene		$12,000,000	Under Constr	Late 1960	ICI		
		Vinylidene Chloride							
		Methyl Chloriform							

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Du Pont	Orange,	Polyethylene			Under Constr				
	Beaumont,	Caprolactam	50,000,000 lbs/yr		Under Constr	Late 1960		Staff	Staff
	Texas	Acrylonitrile			Under Constr	Spring 1962	Staff	Staff	Staff
		Sulfuric Acid			Engineering	1961	Chemico	Chemico	Chemico
Eastern States Petroleum & Chem.	Houston	Exp. Refinery			Planning				
El Paso Natural Gas	Terrell County, Texas	Treating	220 MMcf	$4,827,000	Under Constr	Dec 1960		Fluor	
	Pecos County, Texas	Gas Treating	50 MMcf		Planning				
El Paso Natural Gas Products	Odessa, Texas	*Exp. Styrene	80,000,000 lbs/yr		Under Constr	Late 1960		Staff	Staff
Esso Standard		*Ethylene	150,000,000 lbs/yr		Engineering	Late 1961		UOP/Fish	Fish
	Baton Rouge, La.	Exp. Butyl Rubber, Stage II	18,000 tons/yr	$8,000,000	Under Constr	Mid 1961			
Ethyl	Houston	Vinyl Chloride Monomer			Under Constr	Early 1961			
Firestone	Orange, Texas	Polyisoprene, Polybutadiene	30,000 tons/yr		Under Constr	Dec 1960			
Goliad/Union Oil of Cal.	Vermillion Parish, La.	Natural Gasoline	450 MMcf	$4,000,000	Under Constr	Late 1960		Fluor	Fluor
	Ascension Parish, La.	*LPG Fractionation	20,000 bbls		Under Constr	Late 1960		B & R	Mid-Valley
Goodrich Gulf Chemicals	Port Neches, Texas	Polyolefins, High-Density Polyethylene	13,000,000 lbs/yr		Under Constr	Late 1960	Ziegler	Parsons	Parsons
Goodyear	Beaumont, Tex.	Polyisoprene, Isoprene Polybutadiene			Engineering	Jan 1962		SD	SD
	Houston	*Special Latex Finishing			Engineering	Late 1960		B & R	
Gulf Oil	Port Arthur	Deisobutanizer	10,000 bbls	$600,000	Complete			Treco	Treco
		High Purity Ethylene	1,400,000 lbs		Under Constr	1960		Kellogg/Gulf	Kellogg/Gulf
		Oxo Preparation			Under Constr	1960		Staff/Treco	Treco
Hercules Powder	Lake Charles, La.	Polypropylene	100,000,000 lbs/yr		Under Constr	1961	Staff		
Houston Chemical	Beaumont, Texas	Ethylene Glycol	8–12,000,000 gals/yr	$12,000,000	Engineering	1961			
J.M. Huber	Baytown, Texas	Furnace Blacks	170,000 lbs		Under Constr	Late 1960		Staff	B & R
Humble	Baytown, Texas	Exp. Lub Hydrofiner, Dewaxing, Extraction	6,500 bbls		Under Constr	Late 1960		Fluor	Staff
	Kleberg County, Texas	Gas Process & Cycling	800 MMcf		Under Constr	1960		Hudson	Hudson
Hunt Oil	Alta Loma, Tex.	Natural Gasoline			Planning			Hudson	Hudson
Jefferson Chemical	Conroe, Texas	Morpholine, Polyurethane Resin Intermediates, Speciality Surface-Active Agents			Under Constr	1960		B & R	B & R
	Port Neches, Texas	Processing			Under Constr			Foster Wheeler	
Koppers	Port Arthur	Exp. Polyethylene			Under Constr	1960	Staff	Staff/Badger Mfg	Badger Mfg
Mobil Oil	Beaumont, Texas	Exp. Catalytic Reforming	20,000 bbls		Complete			Fluor	Fluor
		Ethylene	380,000,000 lbs/yr		Under Constr	1961		Kellogg	Kellogg
		Exp. Polyethylene	12,500 bbls	$2,500,000	Planning				
Monsanto Chemical	Gulf Coast	Styrene Monomer	200,000,000 lbs/yr	$30,000,000	Planning	Early 1961			
Morton Chemical	Weeks Island, La.	*Salt Cake	120,000 tons/yr		Under Constr	Early 1961			Kellogg
Pan American Pet.	North Cowden, Texas	Exp. Gas Compression			Under Constr	1960		Staff	B & R
	Old Ocean, Texas	Exp. Refinery			Engineering	Late 1960		B & R	B & R
Petroleum Chemicals	Lake Charles, La.	Exp. Ethylene	100,000,000 lbs/yr		Under Constr			Lummus	
		Ammonia			Under Constr			Foster Wheeler	Foster Wheeler
Phillips Chemical	Borger, Texas	Exp. Synthetic Rubber	20,000 tons/yr		Under Constr	1960			
		Cis-4 Polybutadiene	20,580 tons/yr		Under Constr	1960		Staff	Staff
	Orange, Texas	Carbon Black	60,000,000 lbs/yr		Under Constr	1960		Staff	Stearns Rogers
	Pasadena, Texas	*Exp. Polyethylene	to 30,000,000 lbs/yr		Under Constr	1960		Pioneer	Pioneer
	Sweeny, Texas	Ethylene	160,000,000 lbs/yr		Under Constr	Mid 1961		Braun	Braun
Phillips Petroleum	Borger, Texas	Heavy Oil Cat Cracking	25,000 bbls		Under Constr	Early 1961		Kellogg	Kellogg
		*Natural Gas Liquids			Under Constr	Late 1960			Staff
	Sweeny, Texas	*Exp. Natural Gas Liquids			Under Constr	1961		Braun	Braun
	Etter, Texas	*NH3 Bulk Storage	30,000 tons		Engineering	Spring 1961		Girdler	Girdler
	Abbeville, La.	*Natural Gas Liquids	45,000 MMcf		Under Constr	Late 1960		Stearns Roger	Stearns Roger
Sid Richardson Carbon	Big Spring, Tex.	*Furnace Black	50,000,000 lbs/yr		Engineering	1961	United Carbon	B & R	B & R
Runnels Gas Products/Texas Gas Exploration	Eunice, La.	Exp. Extraction	to 800 MMcf		Planning	Jan 1961		Fluor	Fluor
Shell Oil	Norco, La.	Asphalt Blender, Storage Tanks, Steam Generator			Under Constr				
	Sheridan, Texas	Gas Cycling	150 MMcf	$1,000,000	Planning	Late 1960			
Shell Chemical	Norco, La.	Acrolein			Under Constr				
		Glycerine		$4,500,000	Under Constr	1960		Staff	Parsons/Fluor
Signal Oil & Gas	Houston	*Paraxylene Recovery	15,000,000 lbs/yr	$1,500,000	Engineering	1961		Badger Mfg	Badger Mfg
		*Fluid Cat Cracker & Light Ends			Under Constr	Late 1960		B & R	B & R
Sinclair-Koppers	Houston	*Ethylbenzene, Styrene	70,000,000 lbs/yr	$6,500,000	Engineering	Mid 1961	Cosden	Badger Mfg	Badger Mfg
Sinclair Refining	Houston	*Crude Still	60,000 bbls		Engineering	Mid 1961		Braun	Braun
		Lube Oil			Engineering	Spring 1961		Braun	Braun
		*Ortho-Xylene	70,000,000 lbs/yr		Engineering	Spring 1961		Braun	Braun
South Louisiana Production	Jeanerette, La.	Butane, Propane, Other LPG			Under Constr				
Spencer Chemical	Orange, Texas	Exp. Polyethylene	120-135,000,000 lbs/yr		Complete			Staff	Quaker Valley
Sunray Mid-Continent	Bossier Parrish, La.	Exp. Recovery Facilities	500 MMcf	$500,000	Planning	1960			
Tennessee Oil	Chalmette, La.	*Udex Aromatics Extraction	4,500 bbls	$1,500,000	Engineering	1961	UOP	Badger Mfg	Badger Mfg
	Palacios, Texas	*Natural Gasoline	55 MMcf		Under Constr	Dec 1960		Olsen	Olsen
	Rockport, Texas	*Exp. Natural Gasoline	75 MMcf		Complete			Olsen	Olsen
Texaco	Paradise, La.	Exp. Plant			Engineering	1960		Olsen	
	Port Arthur, Texas	*Hydrotreater	12,000 bbls		Engineering	Early 1962		Staff	
Texas Eastman	Longview, Texas	Polypropylene	20,000,000 lbs/yr		Under Constr			Staff	Hudson
Texas-U.S. Chemical	Port Neches, Texas	Exp. Carbon Black-Synthetic Rubber 10%	to 156,000 tons/yr		Under Constr	Late 1960-Early 1961		Tellepsen Petro-Chem Constructors	
Tidewater Oil	Houma, La.	Natural Gasoline	75 MMcf	$1,900,000	Complete			Olsen	Olsen
Transcontinental Gas Pipe Line	Tilden, Texas	Sulfur Recovery			Planning				
Union Carbide	Seadrift, Texas	Ester & Alcohol	100,000,000 lbs/yr		Engineering	1960			
		Exp. Petrochemicals			Under Constr	1960		Staff	B & R
	Brownsville, Texas	Chemical Solvents, Intermediates		$2,500,000	Under Constr	March 1961			B & R
United Carbon	Houston	Polymer Development Lab.		$2,500,000	Planning				
Valera Oil	Tye, Texas	Propane, Butane, Natural Gasoline	5 MMcf		Complete			Portable Gasoline Plants	Portable Gasoline Plants
Warren Petroleum	Fostoria, Texas	*Gas Products Recovery	30,000 MMcf	$600,000	Under Constr	1960		Staff	Staff

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Western Nat. Gas	Brownsville, Texas	Refinery Revamp	3,500 bbls	.....	Under Constr	.....	.....	.....	Staff
		Exp. Refinery	12,500 bbls	$2,500,000	Planning	.....	.....	.....	.....
Wickett Refining	Wickett, Texas	Platformer	1,500 bbls	$350,000	Planning	Nov 1960	UOP	J C Hinds	J C Hinds

Rocky Mountain

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
American Gilsonite	Grand Junction, Colo.	Exp. Coking	1,100 tons	.....	Planning	.....	.....	.....	.....
Husky Oil	Cody, Wyo.	Refinery	9,000 bbls	$5,400,000	Under Constr	Early 1961	.....	UOP	Southwestern Engineering
Pan American Petroleum/Hondo Oil & Gas	Artesia, N.M.	Natural Gasoline	20 MMcf	.....	Under Constr	1960	.....	Olsen	Olsen
Phillips	Artesia, N.M.	Natural Gasoline	35 MMcf	.....	Under Constr	1960	.....	Staff	Staff
Standard-Indiana	Casper, Wyo.	*Crude Distillation	37,000 bbls	.....	Engineering	1961	.....	Bechtel	Bechtel
Susquehanna Western	Riverton, Wyo.	Exp. Sulfuric Acid	to 75,000 tons/yr	.....	Under Constr	.....	.....	.....	.....
Texaco	Casper, Wyo.	Hydrotreater	4,500 bbls	.....	Complete	.....	.....	Texaco	Badger
Utah Oil Refining	Salt Lake City, Utah	Exp. Cat Cracker, Alkylation, Tankage, Water Treating	.....	$1,500,000	Planning	1960	.....	.....	.....

West Coast

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Allied Chemical	El Segundo, Cal.	Ammonium Sulfate	56,000 tons/yr	.....	Under Constr	Late 1960	.....	.....	.....
Borden Chemical	San Francisco	Resins	25,000 tons/yr	.....	Under Constr	.....	.....	.....	.....
		Formaldehyde	22,500 tons/yr	.....	Under Constr	.....	.....	.....	.....
Collier Carbon & Chemical	Los Angeles	Sulfuric Acid	250 tons	.....	Under Constr	Late 1960	Leonard/Monsanto	Braun/Leonard/Monsanto	Braun
		Ammonium Sulfate	150 tons	.....	Engineering	Late 1960	.....	Ebhart	.....
	Rodeo, Cal.	Carbon Calcining	.....	.....	Under Constr	1960	.....	.....	.....
	Wilmington, Cal.	Sulfuric Acid	.....	.....	Under Constr	1960	Monsanto	Braun/Leonard	Braun
Continental Carbon	Bakersfield, California	Carbon Black	30,000,000 lbs/yr	$2,500,000	Under Constr	Mid 1961	.....	.....	.....
Dow Chemical	Torrance, Cal.	Polypropylene	.....	.....	Under Constr	1961	.....	.....	.....
	Kalama, Wash.	Phenol	36,000,000 lbs/yr	.....	Planning	Mid 1961	.....	.....	.....
Golden Eagle Ref.	Los Angeles	Exp. Refinery	to 30,000 bbls	.....	Planning	.....	.....	.....	.....
	Torrance, Calif.	*Exp. Refinery	to 30,000 bbls	$30,000	Planning	Early 1962	.....	UOP	.....
Hercules Powder	Hercules, Calif.	Methanol	8,000,000 gals/yr	.....	Under Constr	Early 1961	.....	.....	.....
		Formaldehyde	50,000,000 lbs/yr	.....	Under Constr	Early 1961	.....	.....	.....
Northwest Petro-Chemical	Anacortes, Wash.	Caustic Chemicals	.....	.....	Planning	.....	.....	.....	.....
Richfield Oil	Everett, Wash.	Refinery	.....	$50,000,000	Planning	1965	.....	.....	.....
	Watson, Calif.	*Catalytic Reformer	20,000 bbls	$10,000,000	Under Constr	Dec 1960	.....	.....	Parsons
Signal Oil & Gas	Bakersfield, Cal.	Exp. Refinery	20,000 bbls	.....	Complete	.....	.....	Parsons/Nofsinger	Parsons
Standard Oil (Calif.)	Richmond, Cal.	Maleic Anhydride	20,000,000 lbs/yr	.....	Under Constr	Early 1961	.....	Badger	Badger
		*Polybutene	.....	.....	Under Constr	.....	.....	.....	.....
		Polymers	.....	.....	Planning	.....	.....	.....	.....
	Honolulu	Refinery	35,000 bbls	$40,000,000	Under Constr	1961	.....	Staff/Bechtel	Bechtel/Hawaiian Dredging
Texaco	Los Angeles	Hydrotreater	.....	.....	Under Constr	April 1961	.....	Foster Wheeler	Foster Wheeler
Union Oil	Wilmington, Cal.	Catalytic Reformer	14,000 bbls						
		Mid-Barrel Unifiner	20,000 bbls						
		Heavy Cat Unifiner	4,000 bbls	$17,000,000	Engineering	1960	Staff/Sinclair-Baker	Braun	Braun
		Diesel-Oil Unifiner	10,000 bbls						
		Gasoline Blending, Offsite Exp.	.....	$1,500,000	Complete	.....	.....	Fluor	Fluor
		CO Boiler	240,000 lbs/hr	$2,500,000	Under Constr	Early 1961	.....	Fluor	Fluor
		H_2S Recovery	.....	.....	.....	.....	.....	.....	.....
Valley Nitrogen	Helm, Cal.	Ammonia	150 tons	.....	Engineering	1960	Chemico	Chemico	Chemico
Wilshire	Sante Fe Springs, Cal.	*Automatic Gasoline Blending	3,500 bbls/hr	$550,000	Under Constr	1960	.....	Braun/Staff	Staff

Canada

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
British American Oil	Clarkson, Ont.	Compounding, Blending & Grease	.....	$2,900,000	Under Constr	.....	.....	Nofsinger	Foster Wheeler
		*CO Boiler	165,000 lbs/hr	$900,000	Under Constr	Summer 1961	.....	Combustion Engineering	Combustion Engineering
	Calgary, Alta.	Exp. Combination, Crude Topping, Vacuum & Thermal Cracking	to 10,000 bbls	$1,100,000	Complete	.....	.....	Staff	Wirtanen
		Reformer Naphtha Desulfurizer	3,500 bbls	$450,000	Complete	.....	.....	Fluor	Fluor
	Montreal	*Udex Aromatics Extraction, Benzene	6,000,000 gals/yr	$2,800,000	Engineering	Spring 1961	UOP	UOP/Foster Wheeler/Staff	Foster Wheeler
	Moose Jaw, Sask.	Cat Reformer	5,400 bbls	.....	.....	.....	.....	.....	.....
British American Oil, et al	Rimbey, Alta.	Gas Processing	326 MMcf	$10,000,000	Under Constr	Nov 1960	.....	Poole-Pritchard Canadian/Staff	Poole-Pritchard Canadian/Staff

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
British Petroleum	Clarkson	Foul Condensate Stripper	.....	$100,000	Engineering	1960	.....	Staff	Staff
		Hydrodesulfuriser	3,500 bbls	$450,000	Engineering	1960	.....	.....	.....
Canadian Chemicals	Edmonton, Alta.	Revamp Petrochemicals	.....	$4,000,000	Engineering	Jan 1961	.....	Staff/B & R	Staff/B & R
		Exp. Refinery	.....	$4,000,000	Planning	.....	.....	.....	.....
Canadian Oil	Carunna, Ont.	Unifiner	5,000 bbls	.....	Under Constr	1960	.....	UOP	Procon
	Bowden, Alta.	Refinery	4,500 bbls	$4,000,000	Complete	.....	UOP	Canadian/Bechtel	Canadian/Bechtel
Carbide Chemicals	Montreal East, Quebec	Exp. Ethylene Oxide, Oxide Derivatives 100%	.....	.....	Under Constr	Early 1961	.....	B & R	.....
		Exp. Polyethylene	to 65,000,000 lbs/yr	.....	Under Constr	Late 1960	.....	B & R	.....
Cities Service Ref.	Trafalgar, Ont.	Avgas Blending	500 bbls	$250,000	Complete	.....	.....	Staff	Staff
		Asphalt	500-1,000 bbls	$400,000	Complete	.....	.....	Staff	Staff
		*Distillate Desulfurization	4,000 bbls	$1,000,000	Under Constr	Early 1961	.....	Procon	Procon
Colombian Carbon (Canada)	Hamilton, Ont.	*Carbon Black	40,000,000 lbs/yr	.....	Engineering	Late 1961	Staff	B & R	.....
Consumers Cooperative Refineries	Regina, Sask.	Naphtha Unifiner	3,000 bbls	.....	Under Constr	.....	.....	.....	.....
		Platformer	3,000 bbls	$2,500,000	Engineering	Nov 1960	UOP	Staff/UOP	.....
Cyanamid of Canada	Welland, Ont.	Nitric Acid	190 tons	.....	Engineering	1960	Uhde	McKee	McKee
Dominion Rubber	Edmonton, Alta.	*Petrochemicals	.....	.....	Engineering	1961	Staff	B & R	B & R
Dow-Canada	Ft. Saskatchewan, Sask.	*Petachlor Phenol	.....	.....	Engineering	1961	Staff	B & R	B & R
Innisfail Operators Committee	Innisfail Field, Alta.	Refinery	10,000 bbls	.....	Planning	.....	.....	.....	.....
		Sulfur Recovery	80 tons	.....	Planning	.....	.....	.....	.....
		Gas Treating	8.7 MMcf	.....	Planning	.....	.....	.....	.....
Irving Refining	St. John, New Brunswick	Hydrogen	.....	.....	Under Constr	1960	.....	Girdler/ Bechtel	Canadian Bechtel
		Crude Desalter	38,500 bbls	.....	Complete	.....	Howe-Baker	Bechtel	Bechtel
		Gas Treating-Sulfur Recovery	.....	.....	Engineering	1960	.....	Parsons	.....
		Refinery:							
		Two-Stage Crude	40,000 bbls						
		Catalytic Cracker	13,000 bbls						
		Catalytic Reformer	7,150 bbls	$45,000,000	Complete	.....	.....	Canadian Bechtel	Canadian Bechtel/Fluor
		Hydrodesulfurization	5,000 bbls						
		Hydrogen Treating	2,500 bbls						
Jefferson Lake Petrochemicals	Calgary, Alta.	Sulfur Recovery	.....	.....	Under Constr	Nov 1960	.....	.....	.....
	Savannah Creek, Alta.	Sulfur Recovery	.....	.....	Under Constr	.....	.....	.....	.....
Monsanto, Canada	Villa La Salle, Que.	Maleic Anhydride	6,000,000 lbs/yr	.....	Planning	Late 1960	.....	SD	SD
Nevis Operators Committee	Nevis, Alta.		125 tons	.....	.....	.....	.....	.....	.....
Nottingham Gas, Carnduff Gas	Saskatchewan	Gas Processing, Treating, Gathering	8.5 MMcf	.....	Engineering	1960	.....	Tellepsen	Tellepsen
Phillips Petroleum	Taylor, B.C.	Refinery, Natural Gas Liquids	.....	.....	Complete	.....	.....	Stearns Roger	Stearns Roger
Regent Refining	Port Credit, Ont.	Catalytic Reformer	4,700 bbls	$1,500,000	Engineering	1960	.....	UOP	Catalytic
		*Benzene	.....	$2,000,000	Engineering	Fall 1961	UOP	UOP	.....
Sogemines	Maitland, Ont.	Synthetic Nitrogen, Ammonium Nitrate, Nitrogen Solutions, Anhydrous Ammonia	.....	$17,000,000	Engineering	1961	Chemico	Chemico	Chemico
		Partial Oxidation Gasification; Carbon Monoxide Conversion; Carbon Monoxide Removal	15 MMcf	$1,800,000	Under Constr	1961	.....	Power-Gas	Power-Gas
Texaco, Canada	Montreal	Sulfuric Acid Alkylation Feed Preparation and Treating	2,200 bbls	.....	Under Constr	.....	.....	Foster Wheeler	Foster Wheeler
Westcoast Transmission	Coleman, Alta.	Gas Processing	.....	$15,000,000	Planning	.....	.....	.....	.....

Latin America

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
ARGENTINA									
Argentine Government	Santa Fe	Naphtha Reforming, Aromatics Extraction	6,300 bbls	.....	Planning	.....	.....	.....	.....
	Mendoza	Topping, Delayed Coking, Catalytic Cracking	28,300 bbls	$30,000,000	Under Constr	Nov 1961	Kellogg	Kellogg	Kellogg
	Salta	Naphtha Reforming	3,150 bbls	.....	Planning	.....	.....	.....	.....
	Buenos Aires	Topping, Naphtha Reforming, Lube Oil	20,000 bbls	.....	Planning	.....	.....	.....	.....
Carbometal	Mendoza	Polyvinyl Choride	4,500 tons/yr	.....	.....	.....	.....	.....	.....
		Acetylene	200 tons/yr	.....	.....	.....	.....	.....	.....
		Plastics	7,500 tons/yr	.....	Planning	.....	Monsanto	Monsanto	Monsanto
Diadema Argentina (Shell)	Buenos Aires	Crude Distillation	30,000 bbls	.....	Planning	1962	.....	.....	.....
		Cat Cracker	16,000 bbls	.....	Planning	1962	.....	.....	.....
Esso S.A. P.A.	Campana	Crude Distillation	41,000 bbls	.....	Under Constr	1960	EREC	Staff	.....
		Cat Cracker	8,500 bbls	.....	Engineering	Mid 1961	EREC	EREC/Kellogg	Tecnastar
Hooker Chemical	.....	Phenol	25 tons	.....	Under Constr	1962	.....	.....	.....
Atanor									
Monsanto	Buenos Aires	Phthalic Anhydride	.....	.....	Under Constr	.....	.....	Foster Wheeler	.....
BRAZIL									
North American Solvay	Sao Paulo	Ethylene Purification	20 tons	.....	Under Constr	1960	.....	Hydrocarbon	Hydrocarbon/ SETAL
Pernambuco State	Pernambuco	Synthetic Rubber	40,000 tons/yr	.....	Planning	.....	.....	.....	.....
Petroleo Brasileiro	Mataripe	Atmospheric & Vacuum Distillation							
		Cat Cracker, Gas Recovery Wax Treating, Lube	52,000 bbls	$30,000,000	Under Constr	1960	Kellogg	Kellogg	Kellogg Brasileira/Montreal, SA
	Rio de Janeiro	Refinery	90,000 bbls	$60,000,000	Under Constr	1961	Houdry/ UOP	Foster Wheeler	.....
	Duque De Caxias Estad. Do Rio de Janeiro	Synthetic Rubber	40,000 tons/yr	.....	Under Constr	1962	.....	Blaw/Knox	.....
	Cubatao-Sao Paulo	Exp. Refinery	110,000 bbls	.....	Under Constr	1960	.....	Petrobras	.....
		Cat Reformer	12,000 bbls						
		Aromatics Extraction	4,750 bbls	$10,000,000	Engineering	Mid 1962	Houdry/ UOP	.....	.....
		Ethane Cracking	3.77 MMcf						
CEN. AMERICA									
Fertilizantes de Centro America (Ferticas), et al	Costa Rica	Nitrogen, Potash & Phosphorous Fertilizers, Urea	650 tons	$10,000,000	Planning	.....	.....	.....	.....
Matias de Calvez	Puerto Barrios	Refinery	3,500 bbls	.....	Under Constr	.....	.....	Lummus	Lummus

* First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Refineria Petrolera de Guatemala, et al	Matias, de Galvez	Refinery	12,000 bbls	.....	Planning	.....	.....	.....	.....
COLOMBIA									
International Petroleum (Colombia)	Cartagena	Ammonia Nitric Acid	300 tons 150 tons	$13,000,000	Engineering	1961	.....	Esso R & E	.....
GUATEMALA									
Breaux Oil Refining	Bridge Puerto Barrios	Refinery	4,000 bbls	.....	Planning	.....	.....	Lummus	Lummus
MEXICO									
Fertilizantes de Monclova, S.A	Monclova	*Nitric Acid	.....	.....	Complete	.....	SBA	SBA	.....
Pemex	Minatitlan	Anhydrous Ammonia	200 tons	$8,000,000	Engineering	Mid 1961	.....	Fluor	Fluor
		Crude	50,000 bbls	$23,000,000	Engineering	Mid 1961	.....	Fluor	Fluor
		Cat Reformer	.....		Engineering	Mid 1961	.....	Fluor	Fluor
		BTX	4,800 bbls						
	Salamanco	Anhydrous Ammonia	200 tons	$8,000,000	Under Constr	Late 1961	.....	Lummus	Lummus
		Topping	40,000 bbls	$13,000,000	Under Constr	Late 1961	.....	Lummus	Lummus
		Cat Reformer	.....						
		Grease	25 tons	$2,100,000	Engineering	Mid 1961	.....	McKee	McKee
	Ciudad Madero	Refinery	135,000 bbls	$43,000,000	Under Constr	March 1961	.....	McKee	McKee
		Cat Cracker	110,000 bbls						
	Poza Rica	Topping	15,000 bbls	$5,000,000	Under Constr	Mid 1961	.....	McKee	McKee
	Atzcapozalco	Polyethylene	25,000,000 lbs/yr	$8,000,000	Engineering	Late 1961	.....	Simon Carver/ McKee	Simon Carver/ McKee
	Reynosa	Exp. Absorption	6 MMcf	.....	Planning	.....	.....	.....	.....
	Cuidad Pemex	Exp. Absorption	7 MMcf	.....	Planning	.....	.....	.....	.....
Synthesis Organica	Mexico City	Exp. Phthalic Anhydride	.....	.....	Under Constr	1960	.....	Foster Wheeler	.....
PANAMA									
Refinera Petroquimica de Panama	Portobelo	Refinery	55,000 bbls	$40,000,000	Engineering	1961	.....	Foster Wheeler	Foster Wheeler
Refineria Panama, SA	Las Minas Bay Colon	Refinery; Petrochemicals	55,000 bbls	$45,000,000	Under Constr	Dec 1961	.....	Kellogg/Bechtel	Bechtel
TRINIDAD									
Federation Chemicals,	Point Lisas	*Anhydrous Ammonia	100 tons	$15,000,000*	Complete	.....	Stami-Carbon	Braun	Braun
		*Sulfuric Acid	200 tons						
		*Urea	70 tons						
		*Ammonium Sulphate	245 tons						
Shell Trinidad	Port Fortin	Distillation Revamp	14,000 bbls	.....	Under Constr	Late 1960	.....	.....	.....
Texaco Trinidad	Pointe-a-Pierre	Crude Distillation	15,000 bbls	.....	Under Constr	.....	UOP	Procon	Procon
		Crude Topping	100,000 bbls	.....	Under Constr	Late 1960	.....	Fluor	Caribbean Bechtel
		Cat Reformer	15,000 bbls	.....	Under Constr	Late 1960	.....	Fluor	Caribbean Bechtel
		Hydrotreater	20,000 bbls	.....	Under Constr	Late 1960	.....	Staff	Caribbean Bechtel
Administracion Nacional de Combustibles Alcohol Y Portland	La Teja	Vacuum Distillation	10,000 bbls	$10,500,000	.....	Late 1960	.....	Kellogg/Staff	Staff
		Cat Cracker	5,000 bbls				.....		
		Cat Reformer	3,000 bbls				.....		
		Gas Concent. & Bottling	.....				.....		
		Gas Sweetening	4,500 bbls				.....		
		Sulfur Recovery	6 tons				.....		
		Power & Offsite Facilities	3,600 kw	$1,5 0,000*	Under Constr	Late 1960	.....		
		CO Boiler	.....				.....		
VENEZUELA							.....	.....	.....
Creole Petroleum	Amuay Bay	Isopentane	1,800 bbls	$1,500,000	Under Constr	Late 1960	.....	Esso Research	Foster Wheeler
Mene Grande Oil	Eastern Venezuela	Compressor Stations	.....	.....	Engineering	1960	.....	B & R	.....

Europe and Africa

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
AFRICA									
AE & CI	Modderfontein	*Synthetic Ammonia	70,000 tons	.....	Under Constr	1960	.....	Staff/ICI/ Power-Gas	Power-Gas
British Petroleum/ Shell Oil	Durban, Natal	Refinery	.....	$70,000,000	Planning	1963	.....	.....	.....
S.A. Coal, Oil & Gas	.....	Hydrogen	.....	.....	Engineering	1960	Hercules	Power-Gas	.....
Sociedade Nacional de Refinacao de Petroleos	Lourenco Marques, Mozambique	Refinery:	.....	.....	Under Constr	Early 1961	.....	Procon	Procon
		Crude	12,000 bbls	.....	.....	.....	.....	.....	.....
		Platformer	2,500 bbls	.....	.....	.....	.....	.....	.....
		Unifiner	2,000 bbls	.....	.....	.....	.....	.....	.....
		Merox	1,500 bbls	.....	.....	.....	.....	.....	.....
Standard-Vacuum Refining of South Africa	Durban, Natal	Exp. Asphalt	4,500 bbls						
		Continuous Oxidizer	300 bbls	$415,000	Complete	1960	.....	Staff	Fraser & Chalmers SA
AUSTRIA									
Power-Gas	Graz	Catalytic Oil Gasification	1.75 MMcf	.....	.....	.....	Power-Gas	Didier	Didier
Oesterreich Mineralolver-Waltung	Schwechat, near Vienna	Crude Distillation	37,000 bbls	.....	Under Constr	Late 1960	.....	Lurgi	Lurgi
		Cat Reformer	7,000 bbls	.....	Under Constr	1961	UOP	Lurgi	Lurgi
		Gas Recovery	14 MMcf	.....	Under Constr	1961	.....	Lurgi	Lurgi
		Cat Cracker	10,000 bbls	.....	Engineering	1962	UOP	Comprimo	Voest
BELGIUM									
Amoco Fina	Antwerp	Petroleum Additives	.....	.....	Planning	Early 1961	.....	.....	.....
Cobenam, S.A.	Antwerp	Ethylene	.....	.....	Engineering	1961	S & W	S & W	.....
Raffinerie Belge de Petroles	Antwerp	Gas-Oil Desulfurizer	6,000 bbls	.....	Under Constr	1960	Institut Francois	Solemca	Solemca
		Two-Stage Vacuum Distillation	5,000 bbls	.....	Under Constr	1960	Staff	Solemca	Staff
	Anvers	LPG & Sulfur Recovery	.....	$1,900,000	Engineering	March 1961	.....	Technip	Oxy France/ Technip
Union Chemique Belge	Ghent	Phthalic anhydride	5,000 tons/yr	2,000,000	Under Constr	Early 1961	Sherwin/ Williams	Badger NV	Badger NV
CANARY ISLANDS									
Compania Espanola de Petroleos, S.A.	Las Palmas	Ammonium Sulfate	365 tons	$13,000,000	Under Constr	1960	Uhde-Texaco	Uhde	Uhde
	Teneriffe	Crude Distillation	50,000 bbls	$6,000,000	Under Constr	Late 1961	UOP	Procon	Procon
		Unifiner-Platformer	15,000 bbls						
		Boilers, Turbogenerators, tanks, Merox, Kerosine, Gas-Oil Unifining	.....	$6,000,000	Under Constr	1962	AEG & VKW Edeleanu	AEG & VKW	AEG & VKW

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Compania Insular del Nitrigeno, S.A.	Gran, Canaria	Vacuum Distillation	7,800 bbls	.....	Under Constr	Mid 1961	.....	Foster Wheeler	Foster Wheeler
		Ammonium Sulfate	330 tons	$10,500,000	Under Constr	Late 1960	Texaco Uhde, Chemibau Linde	Uhde, Man, Chemibau, Linde	Uhde
DENMARK									
Dansk Veedol.....	Kalundborg	Refinery	20,000 bbls	.....	Under Constr	1961	.....	Foster Wheeler	Foster Wheeler
Imperial Chemical Industries	Copenhagen	Polyethylene	.....	$11,200,000	.....	.....	ICI	.....	.....
ENGLAND									
British Chrome & Chemicals	Urlay Nook	Sulfuric Acid	100 tons	.....	Under Constr	1960	Chemiebau	Power-Gas	Power-Gas
British Petroleum....	Isle of Grain	Special Solvents:	30,000 tons/yr	.....	Under Constr	1960	.....	Staff	.....
	Kent	Redistillation, Acid Wash	.....	.....	.....	.....	.....	.....	.....
		Monomer	.....	.....	Under Constr	.....	.....	Power Gas	Power-Gas
Distillers.....	.....	*Catalytic Oil Gasification	10 MMcf	.....	Engineering	Oct 1962	Onia Gegi	H & G	H & G
East Midlands Gas Board	Dinnington	*Catalytic Oil Gasification	3.5 MMcf	.....	Engineering	Late 1961	Onia Gegi	H & G	H & G
Esso Petroleum.....	Milford Haven	Atmospheric Distillation	100,000 bbls	.....	Under Constr	Late 1960	.....	Foster Wheeler	Foster Wheeler
		Powerformer	16,500 bbls						
		Hydrofiner	16,500 bbls						
		Electric Coalescer	31,500 bbls						
		Other Auxiliaries	.....						
	Fawley	Petroleum Additives	.....	.....	Under Constr	.....	.....	Foster Wheeler	Foster Wheeler
		Exp. Petrochemicals	.....	.....	Engineering	Jan 1961	Esso	Foster Wheeler	Foster Wheeler
Imperial Chemical Industries	Wilton	Polypropylene	10,000 tons/yr	.....	Under Constr	Late 1960	.....	.....	.....
		Ammonium Nitrate Granulation	.....	.....	.....	.....	SBA	.....	.....
International Synthetic Rubber	Fawley	*Synthetic Rubber	90,000 tons/yr	.....	Under Constr	1960	.....	.....	Power-Gas
Monsanto.....	Newport	Maleic Anhydride	15,000,000 lbs/yr	.....	Under Constr	Late 1960	SD	SD	SD
Northern Gas Board..	Darlington	Catalytic Oil Gasification	2 MMcf	.....	Under Constr	.....	.....	Power-Gas	Power-Gas
North Eastern Gas Board	Whitby	Natural Gas Reforming	1.25 MMcf	.....	Under Constr	1960	Hercules	Power-Gas	Power-Gas
		Refinery	75,000 bbls	.....	Planning	.....	.....	.....	.....
North Western Gas Board	Ellesmere Port	*Gas Reforming	14 MMcf	.....	Engineering	Late 1961	Onia Gegi	H & G	H & G
	Partington	*Gas Reforming	12 MMcf	.....	Engineering	1962	Onia Gegi	H & G	H & G
Oronite Chem./BP....	.....	p-Xylene, o-Xylene, Benzene, Ethyl Benzene	.....	.....	Planning	.....	.....	.....	.....
South Eastern Gas...	Isle of Grain	Hydrogen	18 MMcf	.....	Under Constr	Late 1960	.....	Woodall-Duckham	Woodall-Duckham
Southern Gas Board..	Portsmouth	Light Distillate Gasification	2 MMcf	.....	Engineering	Late 1960	Onia	H & G	H & G
Union Carbide.....	Fawley	Ethylene Oxide & Derivatives	.....	.....	Under Constr	.....	.....	.....	.....
UK Atomic Energy Authority	.....	High Purity Nitrogen	.....	.....	Complete	.....	Petrocarbon	Petrocarbon	Petrocarbon
Woodall Duckham....	Fulham	Producer Gas	15 MMcf	.....	Engineering	Oct 1961	H & G	H & G	H & G
FRANCE									
Antar-Petroles del' Atlantique	Donges	Crude Topping	75,000 bbls	.....	Under Constr	1961	.....	Technip	Technip
Californie-Atlantique..	Donges	*Paraxylene	2,200 bbls	.....	Under Constr	Jan 1961	Oronite	Oronite	Lummus
Compagnie Francaise de Petrole/ Compagnie Francaise de Raffinage/ Pechelbronn	Strasbourg	Refinery	70,000 bbls	.....	Planning	.....	.....	.....	.....
Esso Standard.....	Port Jerome	Lube Hydrofiner	.....	.....	Under Constr	1961	Esso R & E	Esso R & E/ Lummus	Lummus
Houilleres du Bassin de Lorraine	Carling	*Acetylene	.....	.....	Complete	.....	SBA	SBA	SBA
		*Nitric Acid	.....	.....	Engineering	.....	SBA	SBA	SBA
Naphtachimie.....	Lavera	Exp. Ethylene Oxide	60,000,000 lbs/yr	.....	Under Constr	1960	S D	SFST	SFST
		Exp. Butadiene Recovery	8,000 tons/yr	.....	Planning	.....	.....	Foster Wheeler	Foster Wheeler
		Cat Cracking, Gas Separation	.....	.....	Under Constr	1960	.....	S & W	S & W
		Ethylene Glycol	.....	.....	Under Constr	1960	.....	Naphthachimie	.....
		*Polyisobutene	.....	.....	Engineering	Summer 1961	Cosden	Badger France	Badger France
		Propylene Oxide	.....	.....	Under Constr	1960	.....	Naphthachimie	.....
		Propylene	.....	$1,000,000	Under Constr	Spring 1961	.....	Badger NV/ Badger France	Badger France
Omnium Francais de Petroles		Refinery	75,000 bbls	.....	Planning	.....	.....	.....	.....
Oronite Chemical/ Societe Colifornie-Atlantique	Donges	p-Xylene			Under Constr	1960	Cal Research	Lummus	Lummus
Pechiney/Dow.....	Ribecourt	Polystyrene	.....	.....	Planning	1961	.....	.....	.....
Societe des Produits d'Aquitaine	Chimique	Ammonia	200 tons	$6,000,000	Engineering	1960	.....	Chemico	Chemico
	Lacq	Acetylene from Nat. Gas	75 tons	.....	Under Constr	.....	BASF	BASF/Heurtey	Heurtey
Soc. Nationale des Petroles D'Aquitaine	Lacq	Desulfurization	175 MMcf	.....	Under Constr	1960	.....	Foster Wheeler	Staff
		Natural Gasoline	120 MMcf	.....	Under Constr	1961	.....	Lummus	Staff
		Ethylene	25,000 tons	.....	Under Constr	1960	.....	Hydrocarbon	Staff
		Preliminary Desulfurization	350 MMcf	.....	Under Constr	1961	.....	Technip	Staff
Soc. Vinylacq	Lacq	Vinyl Chloride	.....	.....	Planning	.....	.....	.....	.....
United Carbon.....	Rouen	Carbon Black	50,000,000 lbs/yr	$5,000,000	Planning	1961	.....	.....	.....
EAST GERMANY									
DIA Chemie Ausruestung Berlin	Leuna	Ethylene Aromatics	300,000 lbs	$12,000,000	Engineering	1962	Petrocarbon	Petrocarbon/ H & G	Staff/H & G
German Democratic Republic	Leuna	Ethylene Aromatics	40,000 tons/yr	$12,000,000	Engineering	.....	Petrocarbon	H & G	.....
Leuna-Werk Walter Ulbricht	.....	Urea	.....	.....	Planning	.....	.....	.....	.....
		Ammonium Nitrate	.....	.....	Planning	.....	.....	.....	.....
		Exp. Nitrogen	to 400,000 tons/yr	.....	Planning	1965	.....	.....	.....
Piersterits Nitrogen..	.....	Exp. Nitrogen	to 20,000 tons/yr	.....	Planning	1961	.....	.....	.....
WEST GERMANY									
B.P. Benzin und Petroleum	Dinslaken	Distillation, Cat Reforming, Hydroforming, Copper Chloride	100,000 bbls	.....	Under Constr	1960	.....	Kellogg	Fried Krupp
Chemische Fabrik Holten	Lubwigshaven a Rein	Ethylene Oxide	9,000,000 lbs/yr	.....	Under Constr	.....	S D	S D	.....
Chemische Werke Huls	Marl	Polyethylene	6,000 tons/yr	.....	Planning	1960	Ziegler	Staff	Staff
Deutsche Erdoel.....	Heide	Exp. Refinery	50,000 bbls	.....	Planning	1963	.....	.....	.....
Durag-Nerag.....	Misburg, Hannover	Unifiner, Platformer, Sulfur Recovery	4,500 bbls	.....	Under Constr	1960	UOP	Lurgi	Lurgi
		*Crude Distillation, Thermal Cracker	21,000 bbls	.....	Under Constr	Nov 1960	.....	Lummus	Lummus
		Delayed Coker	3,000 tons						
		Selective Cracker	21,000 bbls	.....	Under Constr	.....	.....	Lummus	Lummus
		Natural Gasoline							
Deutsche Shell.....	Harburg	Refinery:							
		Crude Distiller							
		Cat Reformer	40,000 bbls	.....	Under Constr	.....	.....	Lummus	.....
		Hydrodesulfurization							
	Godorf	Refinery	30,000 bbls	.....	Under Constr	1960	.....	.....	.....

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licenser	Engineering	Contractor
Erdolchemie	Dormagen/ Niederrhein	Propylene Oxide	20,000 tons/yr	.....	Under Constr	1960	Farbenfabriken/ Bayer	Farbenfabriken/ Bayer	Farbenfabriken/ Bayer
		Ethylene	200,000 tons/yr	.....	Under Constr	1960	.....	S & W	S & W
		Ethanol	18,000 tons/yr	.....	Under Constr	1960	Shell	S & W	S & W
		Butadiene	30,000 tons/yr	.....	Under Constr	Late 1960	Esso	Lurgi	Lurgi
		Gasoline Selective Hydrogenation	90,000 tons/yr	.....	Under Constr	1960	BP	BP/Lurgi	Lurgi
		Di-isobutane	30,000 tons/yr	.....	Engineering	Late 1960	Farbenfabriken	Lurgi	Lurgi
Esso A.G.	Koln	Steam Cracker, Ethylene Recovery, Petrochemicals	.....	$11,000,000	Under Constr	June 1961	Esso R & E	Lurgi	.....
Gelsenberg Benzin AG	Gelsenkirchen	Platformer	12,500 bbls	$5,300,000	Under Constr	Dec 1960	UOP	Lurgi	.....
Gewerkschaft Erdol-raffinerie Emsland	Lingen Holt-hausen	Unifiner-Platformer	4,700 bbls	.....	Planning	.....	UOP/ Shell	Lummus	Lummus
		Gas Oil Desulfurizer	5,500 bbls	.....	Planning	.....	UOP/ Shell	Lummus	Lummus
Frisia	Emden	Refinery	30,000 bbls	$17,000,000	Engineering	1960	.....	Parsons	Parsons
Ministry of Coal & Energy	Stralsund	*Catalytic Oil Gasification	4.8 MMcf	.....	Under Constr	.....	Power-Gas	Power-Gas/ Didier	Didier
Olewerke Julius Schindler	Hamburg-Neuhof	Lube Oil Dewaxing	2,500 bbls	$4,000,000	Under Constr	Early 1961	Edeleanu	Edeleanu	Edeleanu
Kali-Chemie	Bad Honningen	Hydrogen	.....	.....	.....	1960	Hercules	Power-Gas	Power-Gas
Oronite Chemical, B.P.	.....	P-xylene, O-xylene, Benzene, Ethyl Benzene	.....	.....	Planning	.....	.....	.....	.....
Rheinische Olefinwerke	Wesseling Bez. Koln	Ethylene	75,000 tons	.....	Under Constr	1961	.....	Braun	Staff
		Ethylene	.....	.....	Engineering	Jan 1961	Kellogg	Braun/Lurgi	.....
Ruhrchemie	Oberhausen-Holten	Polyethylene	.....	.....	Under Constr	1960	Staff	Uhde	Staff/Uhde
Westdeutsch Erdolleitungs	Ruhlermoor	Crude Desalter	5,700 bbls	.....	Engineering	1960	Howe-Baker	Uhde	Uhde
Wintershall, A.G.	Salzbergen	*Atmospheric Vacuum Distillation	300 tons	.....	Under Constr	End 1960	Lummus	Lummus	Lummus
GREECE									
Dow Chemical	.....	Polystyrene Plastic	.....	$1,000,000	Planning	Early 1961	.....	.....	.....
Greek Government	Ptolemaeus, Greece	Ammonia	300 tons	.....	Engineering	Mid 1962	Uhde, Casale	Uhde, Casale	Uhde, Casale
		Ammonium Sulfate	525 tons						
		Ammonium Nitrate	325 tons						
	Aspropygas	LPG	25,000 tons/yr	.....	Planning	.....	.....	.....	.....
ITALY									
Asfalti Bitumi Cementic Derivati, S.A.	Ragusa	Polyethylene	25 tons	.....	Under Constr	.....	.....	BASF	.....
Azienda Nazionale Idrogenazione Combustibil	Ravenna	Butadiene	.....	.....	.....	.....	.....	.....	.....
		Ethylene	22,000 tons/yr	.....	Engineering	1960	Houdry	Catalytic	.....
	Gela, Sicily	*Refinery	.....	.....	Under Constr	.....	Koppers	ANIC	.....
Dow Chemical Italiana	.....	Polystyrene	.....	.....	Under Constr	1962	.....	.....	.....
			.....	.....	Planning	.....	.....	.....	.....
Ftalital, S.p.a.	Italy	Maleic Anhydride	.....	.....	.....	.....	.....	.....	.....
Montecatini Societe Generale per l'Industria Mineraria Chimica	Ferrara	Exp. Polypropylene	2,200,000 lbs/yr	.....	Engineering	.....	S D	S D	.....
	Castellanza	Exp. Formaldehyde	.....	.....	Planning	1960	.....	.....	.....
	Brindisi	Petrochemical	135,000,000 lbs/yr	$300,000	Under Constr	.....	.....	.....	.....
			700,000 tons/yr	$95,000,000	Under Constr	1962	.....	.....	.....
Phillips Petroleum & ANIC	.....	Carbon Black	25,000,000 lbs/yr	.....	Planning	1962	Phillips	.....	.....
Purfina Italiana	Rome	Refinery	.....	.....	.....	.....	.....	.....	.....
	Genoa	Topping Revamp	20,000 bbls	$10,000,000	Planning	1962	.....	.....	.....
		Trickle Hydrodesulfurization	13,000 bbls	$500,000	Engineering	1961	.....	Staff	Staff
Sincat	Priolio, Sicily	Ethylene	2,200 bbls	$500,000	Engineering	1961	Shell	CTIP	Staff
		Treating	.....	.....	Under Constr	1960	S & W	S & W	.....
Snia Viscosa	Varedo, near Milan	Carbon Disulfide	.....	.....	Engineering	1960	.....	S & W	.....
Union Carbide Societa Edison S.A.	Sicily	Polyethylene	.....	.....	Under Constr	1960	Food	.....	.....
	Celene	Ethylene Oxide	15,000 tons/yr	.....	Under Constr	1960	.....	.....	.....
Malta Gas Board	Valetta	Catalytic Oil Gasification	26,500,000 lbs/yr	.....	Under Constr	1960	.....	.....	.....
NETHERLANDS			1 MMcf	.....	Under Constr	1960	.....	Power-Gas	Power-Gas
N.V. Mattschappij Tot Exploitatie Van Kooksovengossen	Ijmuiden	Gas Reforming	.....	.....	.....	.....	.....	.....	.....
		CO Conversion	4.4 MMcf	.....	Planning	.....	.....	.....	.....
			.....	.....	Planning	.....	.....	.....	.....
Staatsmijner in Limburg	Geleen, Holland	Phthalic Anhydride	.....	.....	Under Constr	1960-1961	S D	SFST	.....
NORWAY									
A/S Esso-Raffineriet, Norge	Slagentangen (Oslo Fjord)	Refinery	40,000 bbls	.....	Under Constr	Late 1960	Esso	Bechtel	Bechtel-Sverdrup
POLAND									
Polimex	Oswiecim	Polystyrene	35,000 bls	$1,500,000	Under Constr	1960	Petro-carbon	Petrocarbon	Staff
Polish Government	Plock	Refinery	.....	.....	.....	.....	.....	.....	.....
		Hydrogen	40,000 bbls	.....	Planning	1965	.....	.....	.....
		Fuel Gas	1.5 MMcf	.....	.....	.....	.....	.....	.....
			11 MMcf	.....	.....	.....	.....	.....	.....
RUMANIA									
Rumanian Govt.	Teleajen	Lube Oil	.....	.....	.....	.....	.....	.....	.....
		Natural Gas Treating	.....	.....	Planning	.....	.....	.....	.....
	Borzesti	Petrochemical	.....	.....	Planning	.....	.....	.....	.....
	Onesti	Synthetic Rubber	.....	.....	Planning	.....	.....	.....	.....
			.....	.....	Planning	.....	.....	.....	.....
SCOTLAND									
British Hydrocarbon Chemicals	Grangemouth	Exp. Styrene Monomer	50,000 tons	.....	Under Constr	Dec 1960	Mon-santo	Monsanto	Matthew-Hall
		Methanol	.....	.....	.....	.....	.....	.....	.....
		Butadiene	.....	.....	Planning	1961	.....	Chemico	Chemico
		Ethylene Dichloride	.....	.....	Under Constr	Spring 1961	Esso	Fluor	Fluor
Scottish Gas Board	Fifeshire	Stage 1, Pressure Gasification	.....	.....	Planning	1961	Ethyl	Lummus	Lummus
			5 MMcf	.....	Under Constr	Late 1960	Lurgi, et al	H & G	H & G
		Stage 2, Pressure Gasification	15 MMcf	.....	Engineering	.....	Lurgi, et al	H & G	H & G
SOUTH AFRICA									
AE & CI	Modderfontein	Synthetic Ammonia	70,000 tons	.....	Under Constr	1960	.....	Staff/ICI/ Power-Gas	Power-Gas
Phillips Petroleum-Industrial Development	.....	Carbon Black	22,000,000 lbs/yr	.....	Under Constr	.....	Staff	Staff	Staff
Standard Vacuum	Durban	Exp. Asphalt Oxidizer	2,100 bbls	$415,000	Under Constr	1960	.....	Staff	.....
			600 bbls						
SPAIN									
Repesa	Escombreras (Marcia) Spain	Ammonia	325,000,000 lbs	$32,000,000	Engineering	1962	Texaco	Foster Wheeler	Foster Wheeler
		Ammonium Sulfate	600,000 tons					Uhde	Uhde
		Urea	210,000 tons					Chemico	Chemico
		Sulfuric Acid	455,000 tons					Braun	Braun
SWITZERLAND									
Miranco	Mendrisio	Lube Oils	500 bbls	$1,500,000	Under Constr	Late 1960	.....	Staff	.....
Power-Gas	Winterthur	Catalytic Oil Gasification	606 MMcf	.....	Under Constr	.....	Power-Gas	Power-Gas Didier	Power-Gas Didier

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
TURKEY									
Istanbul Petrol Raffinerisi Anonim Sirkett (Caltex & Turkish Govt.)	Izmit	Refinery: Crude Distillation Naphtha Unifiner, Platformer, Distillate Hydrotreater, Cat Cracker	20,800 bbls	.....	Engineering	Jan 1962	.....	Kellogg	Kellogg
U.S.S.R.									
Techmachimport.....	Angarsk, Siberia	Polstyrene	5,000 tons/yr	$1,800,000	Engineering	.....	Bx Plastics	Power-Gas	.....
		Acetylene	.....	.....	Engineering	.....	SBA	SBA	SBA
		Synthetic Ammonia	.....	.....	Engineering	.....	SBA	SBA	SBA
YUGOSLAVIA									
Yugoslav Govt.....	Sisak	Topping	15,000 bbls						
		Delayed Coking	4,950 bbls	$10,000,000	Planning	Spring 1963	.....	.....	.....
		Platforming	3,020 bbls						
	Kutina	Ammonia	.....	.....	Planning	.....	.....	.....	.....
	Zagreb	Petrochemicals	.....	.....	Planning	.....	.....	.....	.....
	Rijeka	Topping	1,000,000 tons/yr						
		Delayed Coking	125,000 tons/yr	.....	Planning	.....	.....	.....	.....
		Naphtha Rerunning	140,000 tons/yr						
		Platforming	100,000 tons/yr						
		Sulfur Recovery	5,000 tons/yr						
	Bosanski Brodl	Topping	640,000 tons/yr	.....	Planning	.....	.....	.....	.....

Near East

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
ALGERIA									
Cie Francaise des Petroles	Algiers	Refinery	44,000 bbls	.....	Engineering	1962	.....	.....	.....
EGYPT									
Anglo-Egyptian Oilfields	Suez	Cat Reformer	2,300 bbls	.....	Planning	.....	.....	.....	.....
Egyptian Chem. Ind./ KIMA S.A.E.	Aswan	Ammonia	415 tons	.....	Under Constr	1960	Uhde/ BASF	Uhde/BASF	Uhde/BASF
Egyptian Government	Suez	Power	10,000 kw	$2,200,000	Planning	1960	.....	.....	.....
		Atmos. Distillation Vac. Distillation & Lube Oils	20,000 bbls	$7,000,000	Planning	1960	.....	.....	.....
		Cat Reformer	3,000 bbls	$2,700,000	Planning	1962	.....	.....	.....
		Hydrodesulfurizer	2,700 bbls	$720,000	Planning	1962	.....	.....	.....
		Lube Oils	.....	$9,000,000	Planning	1963	.....	.....	.....
	Alexandria	Atmos. & Vacuum Distillation	10,000 bbls	$1,400,000	Planning	.....	.....	.....	.....
	Cairo	Atmos. Distillation & Vacuum, Distillation	10,000 bbls	$1,400,000	Planning	.....	.....	.....	.....
IRAN									
Iranian Govt.....	Shiras	Nitric Acid	30,000 tons/yr	$30,000,000	Under Constr	.....	SBA	SBA/Foster Wheeler	John Brown
		Ammonium Nitrate	.....	.....	Under Constr	.....	SBA	SBA/Foster Wheeler	.....
IRAQ									
Iraq Petroleum.....	Kirkuk	Oil Sweetening	250,000 bbls	$1,250,000	Under Constr	Sept 1961	.....	Foster Wheeler	Foster Wheeler
		*Oil Sweetening	400,000 bbls	.....	Planning	Jan 1962	.....	Staff/Foster Wheeler	Foster Wheeler
KUWAIT									
Kuwait Oil.....	Mina al Ahmadi	Bulk LPG	8,000 bbls	.....	Engineering	1961	.....	Wimpey-Bechtel International	Wimpey-Bechtel
MOROCCO									
Ente Nazionale Idrocarburi	Mohammedia	Refinery	25,000 bbls	.....	Under Constr	1962	.....	.....	.....
PAKISTAN									
Pakistan Industrial Development	Frnchanj	Ammonia	225 tons	$20,000,000	Engineering	1961	Kobe Steel	Chemico	Chemico
		Urea	375 tons	.....	.....	.....	.....	.....	.....
Standard Vacuum Oil, et al	Korangi	Refinery: Crude Distillation Hydrotreater Catalytic Reformer	32,000 bbls	$35,000,000	Engineering	.....	.....	.....	.....
Sui Carbon.....	.....	Carbon Black	36,000,000 lbs/yr	.....	Planning	.....	.....	.....	.....
SAUDI ARABIA									
Arabian American Oil	Ras Tanura	Alkylation	1,210 bbls	$6,990,000	Under Constr	1960	Kellogg	Kellogg/Staff	Staff
		LPG	1,500 bbls	$1,025,000	Engineering	1961	Kellogg	Staff	Staff
		Asphalts	.....	.....	Under Constr	.....	.....	.....	.....
United Arab Republic	Suez	Exp. Refinery	.....	.....	Engineering	.....	UOP/ Others	Braun	.....
Arabian Oil of Japan	Kuwait	Topping & Utilities	20,000 bbls	.....	Planning	1962	.....	.....	.....
		Refinery	50,000 bbls	.....	Planning	1965	.....	.....	.....
TURKEY									
Caltex, Standard Oil (Calif.), Turkish Govt.	Izmit	Refinery: Crude Distillation Naphtha Unifiner Platformer Distillate Hydrotreater Catalytic Cracker	20,800 bbls	$26,000,000	Engineering	.....	.....	.....	Kellogg
Caltex.....	Istanbul	Refinery	.....	.....	Engineering	.....	.....	.....	.....
Mobil International, Royal Dutch Shell BP	Mersin	Refinery: Crude Distillation, Naptha Pretreating, Naptha Catalytic Reforming, Kerosine Catalytic Hydrodesulfurization	65,000 bbls	$48,000,000	Under Constr	Oct 1961	.....	Foster Wheeler	Foster Wheeler

Far East

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
COMMUNIST CHINA									
	Lanchow Shenyan	Refinery	.....	.....	Under Constr	.....	.....	....	.....

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
FORMOSA									
Chinese Petroleum	Kaohsiung	Unifiner	5,500 bbls	$900,000	Engineering	Late 1960	Union Oil	Fluor/Staff	Staff
		*Catforming	5,000 bbls	.....	Planning	.....	.....	.....	.....
Pioneer Chemical	Taipei	*Coke Distillation	36 tons	.....	Engineering	.....	.....	Ishii Iron Works	.....
INDIA									
Fertilizers & Chemicals Travancore	.....	Partial Oxidation Gasification	.....	.....	Engineering	.....	Texaco	Power-Gas	Power-Gas
		Carbon Monoxide Pressure Conversion	.....	.....	Engineering	.....	Power-Gas	Power-Gas	Power-Gas
		Carbon Dioxide & Hydrogen Sulphide Removal	.....	.....	Engineering	.....	Power-Gas	Power-Gas	Power-Gas
	Barauni	Refinery	40,000 bbls	.....	Planning	1962	.....	USSR Govt	USSR Govt
Neyveli Lignite	Neyveli	Urea	500 tons	$52,500,000	Engineering	Early 1963	.....	Montecatini/ Ansaldo	Montecatini/ Ansaldo
Oil India Private	Noonmati, Assau	Refinery	750,000 tons/yr	$10,500,000	Under Constr	April 1961	Indian Govt	Rumanian Govt	Rumanian Govt
Phillips Carbon Black	Durgapur	Carbon Black	22,000,000 lbs/yr	.....	Under Constr	Late 1961	.....	.....	.....
Sahu Chemicals	Varanasi	Ammonium Chloride	120 tons	.....	Under Constr	1960	Uhde	Uhde	Uhde
		Soda Ash Fertiliser	120 tons	.....	Under Constr	1960	Pintsch/ Bamag	Pintsch/Bamag	Pintsch/Bamag
		Ammonia	120 tons	.....	Under Constr	1960	John Thompson	CECIP	John Thompson
Standard Vacuum	Bombay	Asphalt	125,000 tons/yr	$2,500,000	Under Constr	1960	.....	Parsons	Parsons
INDONESIA									
Indonesian Govt.	Palembaug, Sumatra	Urea Fertilizer	330 tons	.....	Under Constr	.....	.....	Foster Wheeler	Foster Wheeler
JAPAN									
Asahi Chemical Industries	Nobeoka	NH_3 Synthesis Gas	50 metric tons	$3,670,000	Under Constr	1960	Texaco/ Chemico	Chemico	Chemico
Asia Oil	Yokohama	Unifiner	3,000 bbls	$1,000,000	Engineering	Sept 1961	UOP	UOP/JGC	JGC
		Unifiner-Platformer	5,000 bbls	$3,770,000	Engineering	Sept 1961	UOP	UOP/JGC	JGC
		Merox	4,000 bbls	$119,000	Engineering	Feb 1961	UOP	UOP/JGC	JGC
		*Topping Desalter	30,000 bbls	$1,980,000	Engineering	Feb 1961	.....	Chiyoda	Chiyoda
		*Gas Concentration	1.6 MMcf	$511,000	Engineering	Sept 1961	.....	UOP/JGC	JGC
	Hakodate	*Vacuum Distillation	1,500 bbls	$319,000	Complete	.....	.....	JGC	JGC
Daikyo Oil	Yokkaichi	Merox	6,000 bbls	.....	Planning	.....	UOP	UOP/JGC	JGC
Furukawa Chemical Industries	Japan	Platforming	5,000 bbls	.....	Planning	.....	UOP	UOP/JGC	.....
Fuji Iron & Steel	Himeji	Unifining, Udex	700 bbls	.....	Engineering	.....	UOP	UOP/JGC	JGC
General Oil	Kawasaki	Merox	5,700 bbls	.....	Engineering	Oct 1961	UOP	UOP/JGC	JGC
Japan Synthetic Rubber	Yokkaichi	*Exp. Petrochemicals	to 45,000 tons/yr	.....	Planning	1963	Houdry/ Goodyear/ Esso	Blaw-Knox/ Catalytic/ Chiyoda/JGC	Chiyoda JGC
Koa Oil	Iwakuni	Delayed Coker	4,500 bbls	.....	Under Constr	1960	UOP	UOP/JGC	JGC
		Unifining	.....	.....	Planning	.....	UOP	UOP/JGC	JGC
		Merox	.....	.....	Planning	.....	UOP	UOP/JGC	JGC
Kokan Chemical Industries	Kawasaki	Ethylbenzene	328 bbls	.....	Engineering	Oct 1961	UOP	UOP/JGC	JGC
		Styrene Monomer	13,000 tons/yr	.....	Engineering	Oct 1961	UOP	UOP/JGC	JGC
Kyowa Fermentation Industry Co., Ltd.	.....	Acetaldehyde	45 tons	.....	Planning	.....	Knapsack-Griesheim	Uhde	Uhde
	Ube	Butanol, Octanol, Acetylene, Ethylene	.....	$13,500,000	Planning	.....	.....	Iion-Tears	Iion-Tears
			.....	$6,500,000	Planning	.....	.....	.....	.....
Maruzen Oil	Matsuyama	Unifiner	4,000 bbls	.....	Engineering	1960	UOP	UOP/JGC	JGC
		Udex	1,500 bbls	.....	Engineering	Feb 1961	UOP	UOP/JGC	JGC
	Shimotsu	Unifiner-Platformer	6,000 bbls	.....	Engineering	Feb 1961	UOP	UOP/JGC	JGC
		Unifiner	4,500 bbls	.....	Planning	April 1961	UOP	UOP/JGC	JGC
Mitsubishi Oil	Mizushima	Merox	2,000 bbls	.....	Planning	1960	UOP	UOP/JGC	JGC
		*Refinery	22,000 bbls	$40,000,000	Engineering	Early 1962	.....	.....	Chiyoda/JGC
		Unifiner	.....	.....	Planning	.....	UOP	UOP/JGC	JGC
		Unifiner-Platformer	3,600 bbls	.....	Engineering	July 1961	UOP	UOP/JGC	JGC
Mitsubishi Petrochemical	Yokkaichi	Unifiner-Udex	1,606 bbls	.....	Engineering	June 1961	UOP	UOP/JGC	JGC
		Ethylene	22,000 tons/yr	.....	Engineering	July 1961	S & W	S & W/JGC	JGC
		*Polyethylene	41.1 tons	.....	Engineering	July 1961	BASF	BASF/Mitsubishi Chemical Machinery	Mitsubishi Chemical Machinery
Nihon Synthetic Rubber	Yokkaichi	Exp. Petrochemicals	to 45,000 tons/yr	.....	Under Constr	1963	.....	.....	.....
Nippon Mining	Mizushima	Unifiner	2,000 bbls	.....	Engineering	.....	UOP	UOP/JGC	JGC
		Unisol	2,500 bbls	.....	Engineering	.....	UOP	UOP/JGC	JGC
		Cat Reforming	6,000 bbls	.....	Under Constr	.....	.....	Houdry	Houdry
		Hydrodesulfurization	8,000 bbls	.....	Under Constr	.....	Houdry	Catalytic/ Niigata	Catalytic/ Niigata
Nippon Petrochemicals/Oronite Chemical	Kawasaki	Alkyl Benzene	15,000 tons	$4,000,000	Planning	June 1961	Cal Research	.....	.....
		Unifiner-Udex	800 bbls	.....	Planning	Aug 1961	UOP	UOP/JGC	UOP/JGC
		Isopropanol	6,000 tons/yr	$2,500,000	Planning	Dec 1960	Distiller	S & W	.....
		Acetone	6,000 tons/yr						
Nippon Petroleum Refining	Yokohama	Cat Cracker	7,500 bbls	.....	Engineering	June 1961	UOP	UOP/JGC	JGC
Nilto Chemical Industry	.....	Synthesis Gas	125 tons	$6,000,000	Planning	.....	Texaco	Iino-Tears	Iino-Tears
Osaka Gas	Osaka	Catalytic Oil Gasification	20 MMcf	$1,800,000	Under Constr	Late 1960	Onia Gegi	H & G	Ishii Iron
Showa Denko KK	Tokyo	Carbon Black	.....	.....	Under Constr	.....	Phillips	.....	.....
Showa Oil	Kawasaki	Unifiner-Platformer	6,000 bbls	.....	Engineering	Oct 1961	UOP	UOP/JGC	JGC
		Merox	.....	.....	Planning	.....	UOP	UOP/JGC	JGC
Sumitomo Chemical/ SBA	Niihama City	Acetylene-Ethylene	.....	.....	Engineering	.....	SBA	SBA	.....
Tokai Ryuan K.K.K.	.....	High Pressure H_2S & CO Conversion, CO_2 Removal	500,000 cu ft/hr	.....	Engineering	.....	Power-Gas/ Ventrocoke	Power-Gas	.....
Toyo Koatsu	Shimonoseki	Ehanolamines	150 tons	.....	Under Constr	1960	Staff/JGC	Staff/JGC	JGC
Ube Kosan	.....	Ammonia	100 tons	.....	Under Constr	1960	.....	Chemico	Chemico
		Ethylene	21,000 tons/yr	.....	Planning	.....	.....	.....	.....
		Polyethylene	20,000 tons/yr						
		Polypropylene	5,000 tons/yr						
KOREA									
Korean Government	Naju	Urea	95,000 tons/yr	.....	Engineering	1962	Inventa	Lurgi/Uhde	Lurgi/Uhde
Korea Petroleum	Ilsan	Refinery	20,000 bbls	.....	Planning	.....	.....	.....	.....
MALAYA									
Shell of Singapore	Singapore, Malaya Peninsula	Refinery	.....	$13,300,000	Planning	.....	.....	.....	.....
Shell of Malaya	.....	Refinery	.....	$20,000,000	Planning	.....	.....	.....	.....

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Standard Vacuum	.....	Refinery, Chemical Fertilizers	.....	.....	Planning	.....	.....	.....	.....
SINGAPORE									
Maruzen Oil, Toyo Manka Kaisha	Pasir Panjang	Refinery	20,000 bbls	.....	Planning	Dec 1961	.....	.....	.....
THAILAND									
Thai Defense Ministry	Bangkok	Refinery	5,000 bbls	$20,000,000	.....	.....	.....	Japanese Fuji	Japanese Fuji

Australasia

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
AUSTRALIA									
Australian Oil Refining	Kurnell	Exp. Refinery:	.....	.....	.....	1961	UOP/ Kellogg	Kellogg	.....
		Crude	45,000 bbls	.....	.....	.....	.....	.....	.....
		Cat Cracker	18,000 bbls	.....	.....	.....	.....	.....	.....
		Alkylation	3,400 bbls	.....	.....	.....	.....	.....	.....
Australian Synthetic Rubber	Altona	Synthetic Rubber	.....	$10,000,000	Under Constr	Summer 1961	.....	Fluor	Fluor/Utah
Bitumen & Oil Refineries	Sydney	Diesel Unifiner	2,500 bbls	.....	Under Constr	.....	.....	UOP	Staff
		Crude	12,000 bbls	.....	Planning	.....	.....	Procon	Procon
CSRC Dow Pty.	Altona	Styrene	.....	.....	Under Constr	July 1961	.....	.....	Bechtel/McDonald/Wimpey & Coy
Gas & Fuel	Melbourne	*Catalytic Oil Gasification & Gas Reforming	10 MMcf	.....	Engineering	1962	Onia Gegi	H & G	H & G
Geelong Gas	Geelong	Refinery Gas Reforming	3 MMcf	.....	Engineering	1961	Onia Gegi	H & G	H & G
Imperial Chemical Industries of Australia & New Zealand	Botany	Polyethylene	25,000 tons/yr	$5,040,000	Under Constr	.....	.....	.....	.....
Shell Chemical	Clyde	Resins, Alkylates	.....	$22,000,000	Planning	.....	.....	.....	.....
		Cat Cracker	.....	$38,000,000	Under Constr	1963	.....	.....	.....
		Ethylene	.....	$22,400,000	Engineering	Early 1961	.....	Braun	Braun
Shell Oil	Newport	Oil Blending	.....	.....	.....	.....	.....	.....	.....
Shell Refining (Australia)	Clyde	Cat Cracker	24,000 bbls	.....	Planning	Late 1962	.....	.....	.....
	Geelong	Hydrodesulfurizer	11,000 bbls	.....	Planning	1960	.....	.....	.....
Standard Vacuum	Adelaide	Refinery	30,000 bbls	$30,000,000	Planning	1962	.....	.....	.....
	Altona	Petrochemicals (Ethylene & Butadiene)	20,000 tons/yr	$28,000,000	Under Constr	Spring 1961	.....	Fluor	Fluor/Utah
Union Carbide	Melbourne	Polyethlene	15,000,000 lbs/yr	.....	Planning	1961	.....	.....	.....
PHILIPPINE ISLANDS									
Filoil Refining	Luzon	Refinery	10,000 bbls	.....	Planning	Late 1960	.....	.....	.....
Shell (Philippines)	Manila	Refinery	.....	.....	Planning	.....	.....	.....	.....
Standard Vacuum	Bataan	Refinery	25,250 bbls	$35,000,000	Under Constr	Late 1960	.....	Foster Wheeler	Foster Wheeler

*First appearance in tabulation.

Boxscore Abbreviations

Atlantic—Atlantic Ref. Co.
Austin—The Austin Co.
Badger N. V.—Badger N. V., Netherlands
Badger Mfg.—Badger Mfg. Co.
B & R—Brown & Root, Inc.
BASF—Badische Anilin & Sod. Fab.
Bechtel—Bechtel Corp.
Blaw-Knox—Blaw-Knox Co.
Braun—C F Braun Co.
Calif. Res.—California Research Corp.
Canadian Badger—Canadian Badger Company Limited
Canadian Bechtel—Canadian Bechtel Limited
Catalytic—Catalytic Construction Co.
Chemical Projects Assoc.
Chemico—Chemical Construction Co.
CTIP—Compagnia Technica Industria Petroli
Dresser—Dresser Engineering Corp.
Ehrhart—Ehrhart & Associates, Inc.
Esso—Esso Research and Engineering Co.
Ferguson—H. K. Ferguson Co.
Fluor—Fluor Corp.
Food—Food Machinery & Chem. Corp.
Foster Wheeler—Foster Wheeler Corp.
Girdler—Girdler Construction Division, Chemetron Corp.
H & G—Humphrey & Glasgow
Hudson—Hudson Engineering Corp.
Hydrocarbon—Hydrocarbon Research, Inc.
HWP—McKee-Head Wrightson Process, Ltd.
ICI—Imperial Chemicals, Inc.
JGC—Japan Gasoline Co.
Kellogg—The M. W. Kellogg Co.
Kidde Constr.—Walter Kidde Constructors, Inc.
Kidde Engrs.—Walter Kidde Engineers Southwest, Inc.
Koppers—Koppers Co., Inc.
Leonard—Leonard Construction Co.
Litwin—Litwin Engineering Co.
Lummus—The Lummus Co.
Lurgi—Lurgi G. m. b. H.
Macco—Macco Corp.
McKee—Arthur G. McKee Co.
Nofsinger—The C. W. Nofsinger Co.
Olsen—O. L. Olsen Co.
Parsons—The Ralph M. Parsons Co.
Power Gas—Power Gas Corp., Ltd.
Pritchard—J. F. Pritchard Co.
Procon—Procon, Inc.
Quaker—Quaker Valley Constructors
S&W—Stone & Webster Engineering Corp., Chemical Division
S&W Ltd.—Stone & Webster England, Ltd.
SBA—Soc. Belge de L'Azote et des Produits Chimiques du Marly
SD—Scientific Design
SFST—Societe Francais des Services Techniques
Soc. Chimique—Societe Chimique de la Grande Pareisso
Stearns-Roger—Stearns-Roger Mfg. Co.
Sumner Sollitt—Sumner Sollit Co.
Sweco—Southwestern Engineering Co.
Tellepsen—Tellepsen Petro-Chem Constructors
Treco—Refinery Engineering Co.
Uhde—Friedrich Uhde, G. m. b. H.
UOP—Universal Oil Products Co.
Vulcan—Vulcan Cincinnati, Inc.

INDUSTRY IQ QUIZ

(Answers to Quiz on Page 18)

1. True. Photographs can help solve this problem as outlined in the article "Photographs Speed Field Repair Information," Page 173.

2. (c) Dewpoint degrees Fahrenheit. A complete picture of plant testing purposes and results is given in the series, "Operator's Handbook for Gasoline Plants," Page 163.

3. False. Five problems, such as acceleration, can be traced to fuel volatility regardless of the weather. The 32-page report starting on Page 109 takes up these problems with fuels in detail.

4. False. Quite the opposite is true says F. W. Winn in his article on "How to Specify Valve Trays," Page 145. A duty type specification is most often used because tray design procedure is not widely available. Therefore, the purchaser will probably not have the design information to work out the tray details for an equipment specification.

5. False. Both parts of this statement are false. In Mr. Puleo's article on "Relief Valve or Rupture Discs?," Page 157, he says: "The specific gravity of a fluid has little or no effect on the operation of either a rupture disc or a relief valve. Its only effect will be in the relieving capacity of the device and should be taken into account in the sizing calculation of the valve or rupture disc."

6. False. Spare equipment should be held to a minimum consistent with sound economics and good safety practices. This is just one of the many fine points discussed in "How to Get Investment Efficiency" on Page 177.

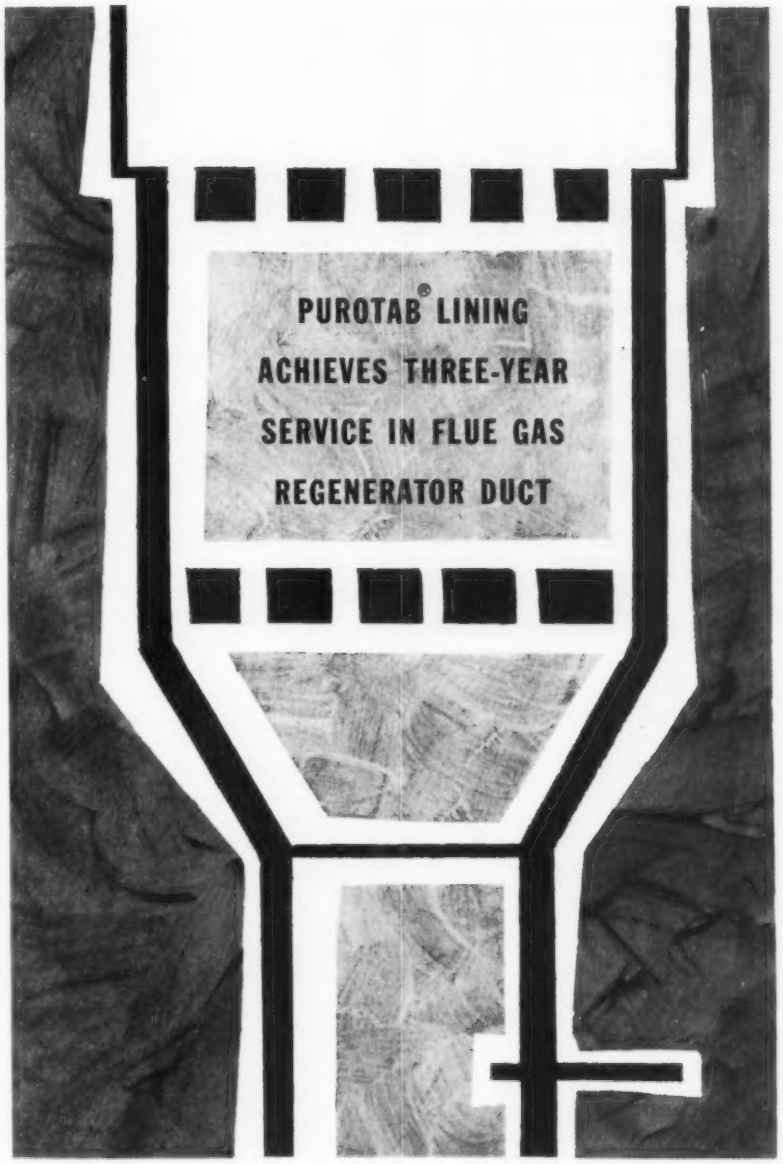
7. True. The way to make these multicomponent calculations of vapor fugacities is explained in Part 22 of Professor Edmister's series. See Page 167.

8. False. The API gravity is increased giving a lighter and more usuable oil. In "H-Oil Process Treats Wide Range of Oils," Page 151, you will find more data on treating other heavy products and also the effect on sulfur and metals content.

9. Usually false. This is one of the definitions of a linear, not nonlinear system, according to expert Dr. Williams in his series "Automation Today," Page 147.

10. False. Standard Oil (Indiana) is using 20 such viscosimeters in its refineries, monitoring viscous materials from light lubricating oils to heavy resins. Details on each of these applications can be found in the article "Process Viscosimeter, Speeds Operation," Page 141.

11. (a) through (c). Warm up is a cold weather problem, as you will see in the comprehensive report on fuel blending for volatility, Page 109.



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What's Happening...

Refining Program Outlined For Annual API Meeting

The program for the Division of Refining at the forthcoming 40th annual meeting of the American Petroleum Institute includes two sessions, both of which will be held in the Grand Ballroom of the Conrad Hilton Hotel in Chicago.

On November 14, a session on operating practices will start at 10 a.m. It is being jointly sponsored by the insurance, safety, fire protection, and operating practices committees of the institute. It continues the series of sessions started in 1958, which are designed to call attention to potential hazards, causes of detonations, and the need to instruct operating personnel in refineries. A feature of the session will be the premiere showing of the Ethyl Corp. film, "Danger! Air!" A. P. Frame, Cities Service Co., will preside.

On November 15, the Division of Refining sessions will start at 10 a.m. Following the presentation of the report of the Nominating Committee and the election of the General Committee, a program on the theme, "Financing Ideas for the Future," will be presented.

Cary R. Wagner, chairman, Petroleum Research Fund Advisory Board; Alan T. Waterman, director, National Science Foundation; and Monroe E. Spaght, chairman, Research Committee, API Board of Directors, will explain the role played by these three institutions that sponsor fundamental research projects of interest to the petroleum industry. Each has its own scope and criteria for approval of potential projects; the differences have resulted in some confusion and misunderstanding. Clarence H. Thayer, vice president, refining, American Petroleum Institute, will preside.

Tentatively scheduled to speak at API general sessions are: Arthur H. Dean, of the law firm of Sullivan and Cromwell, New York, former chief U. N. truce negotiator in Korea; Sen. James F. Murray, Jr., Director of Finance, Jersey City, N. J.; M. J. Rathbone, president of Standard Oil Co. (New Jersey), New York, and chairman of the API Board of Directors; Frank M. Porter, president of the American Petroleum Institute; and William F. Kenney, vice president and general counsel of Shell Oil Co., New York, and chairman of the API Committee on Public Affairs. Rathbone will preside at the general session.

Division of Refining Session

Tuesday, November 15, 10 a.m. Grand Ballroom, Conrad Hilton Hotel, Chicago. Presiding: Clarence H. Thayer, vice president, refining, American Petroleum Institute; vice president, Sun Oil Co., Philadelphia.

- **Report of Division's Nominating Committee, W. H. Price, Cities Service Co., New York.**
- **Election of Members of the General Committee, Division of Refining.**
- **Financing Ideas For the Future: The Petroleum Research Fund, Cary R. Wagner, American Chemical Society, Washington, D. C.**
- **The National Science Foundation, Alan T. Waterman, National Science Foundation, Washington, D. C.**
- **Fundamental Research Program of the American Petroleum Institute, M. E. Spaght, Shell Oil Co., New York.**

For more data on advertised products, use Readers' Service Cards, last page.

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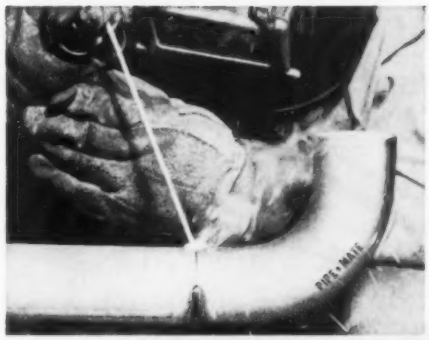

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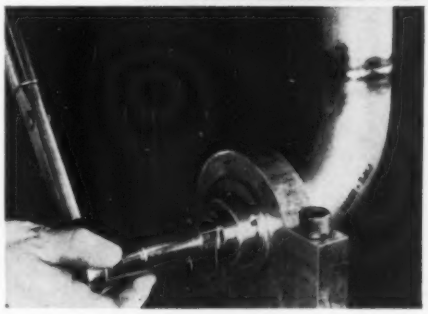

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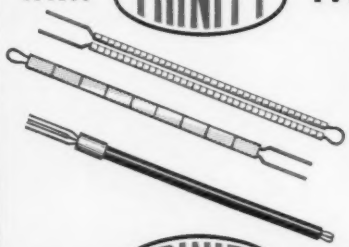

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Happenings . . .

More Instrumentation, Says Humble Executive

The oil industry leads the nation in capital investment—$64,000 per employe compared with about $15,000 for industry in general—but there still is great need for further instrumentation if it is to achieve the progress necessary to our economy, said E. D. Reeves, Humble Oil & Refining Co. vice president and director. Reeves was speaking before the Instrument Society of America's 16th annual convention in New York City.

The oil executive said, the goal of our refineries is full-fledged automatic control, and what we would like to see is a system of instruments and computers into which we could feed market requirements. From there on, the computers would calculate the materials that would be required and send signals to individual processing units as to what they should do to make these products in the most economical fashion. Each unit would then follow instructions through its own system of continuous analyzers, sensing mechanisms, computers, and feedback control units.

He told the society that while greater use of automatic controls and computer systems were essential to the oil industry, he hoped it would not lead anyone to think that such automation would mean throwing people out of work. Instead, he said, it represents "the creation of a new way of life in which each of us can be more productive, a way of life in which we can at last free ourselves from the routine of the production line and spend our working hours in a creative and challenging environment."

Graduate Courses Offered At Baytown Refinery

Seven graduate-level courses are being presented in the 1960-61 Humble Lectures in the Science and Engineering Program at the Baytown, Texas, refinery, Humble Oil & Refining Co.'s Humble Division, two of them by foreign scientists.

Dr. E. O. Fischer, professor in the Institut for Inorganic Chemistry at the University of Munich, taught a course in metal organic compounds, and Dr. Joseph Marin, head of the Engineering Mechanics Department at Pennsylvania State University, presented one in properties of materials during August. The next course scheduled is in mathematical synthesis of physical systems to be given by Dr. Leon Lapidus of Princeton University's School of Engineering.

Dr. M. W. Thring will come from England in November to conduct a course in pilot plants, models and scale-up in chemical engineering. He is a member of the faculty of the Department of Fuel Technology and Chemical En-

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SUN OIL COMPANY'S $2,000,000 PROPYLENE PLANT – recently placed in successful operation at Sun's huge Marcus Hook, Pennsylvania, refinery – has a potential capacity of 120,000,000 pounds of high-purity propylene per year. Reputedly the largest operation of its kind in the United States, designed to produce the high-purity propylene required by manufacturers of polypropylene – Sun's new plant is currently producing a material with 99.9% purity from refinery gas streams. KOCH FLEXITRAYS HELP MAINTAIN THAT PURITY! Type "F" Koch Flexitrays—140 in all – were specified 100% in the two distillation towers that comprise the major equipment in the new plant. Considered the most dependable and economical device yet developed for distillation absorption and stripping, Koch Flexitrays often save refineries and chemical plants 20 to 40% on total cost of completed installations! For YOUR next tower – investigate Koch Flexitray before you specify! The extreme flexibility of this low-cost fractionating tray has led to its use in more than 1500 installations.

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Salt Lake City, Utah, G. M. Wallace & Co., Continental Bank Bldg.
Charleston, W. Va., D. D. Foster Co. 411 "D" Street
St. Louis 17, Mo., Sample Brothers, 2010 Big Bend Blvd.
Tulsa, Oklahoma, Myers Aubrey Co., P. O. Box 5436
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Happenings . . .

gineering at the University of Sheffield.

Dr. R. B. Bird of the University of Wisconsin's Chemical Engineering Department will be in Baytown late this fall to present a course in transport phenomena, and in January, Dr. Henry Margenau of Yale's Physics Department will conduct one in mechanics of atomic systems. The last course in the series will be taught next spring by Dr. R. E. Treybal of New York University's Chemical Engineering Department; it will be in solvent extraction.

Standard, McGraw-Edison In Fuel Research Program

An agreement for joint research and development on fuel cells has been announced by Standard Oil Co. (Indiana) and McGraw-Edison Co. The initial two-year agreement for the project, subject to renewal, calls for combining know-how in their respective fields of Thomas A. Edison Research Laboratory Division, McGraw-Edison, West Orange, N.J., and Standard Oil's Research and Development Department at Chicago and Whiting, Ind.

Standard Oil researchers will contribute their knowledge of catalysis, combustion oxidation, and hydrocarbon or petroleum fuel characteristics. The Edison laboratory specializes in electrochemistry, electrolytes, cell reactions, electrode construction and activation, and electro-chemical cell construction.

A fuel cell is a method of electrochemically oxidizing or burning a fuel and converting it directly to electric energy. The joint project is directed at finding a practical and economical method for oxidizing hydrocarbon, alcohol, or hydrogen as fuel for the cell. A few experimental energy cells already have been developed, but none has been practical enough to meet the requirements for using a cheap fuel that will provide the required power output for commercial use.

High-Temperature Fuels Discussed By Shell Scientist

A paper dealing with two groups of fuels that can withstand the temperature of Mach 3 to 5 flight (three to five times as fast as sound), was presented at the American Chemical Society meeting in September by Walter Appleby of Shell Development Co. Both the fuel groups, naphthenes and paraffins, can be made directly from refinery streams.

It was pointed out by Appleby that fuels for such flight must be heat-resistant because they must provide cooling as well as power. At speeds of Mach 3 to 5, a plane builds up pressure in the air around it that blankets the plane with a

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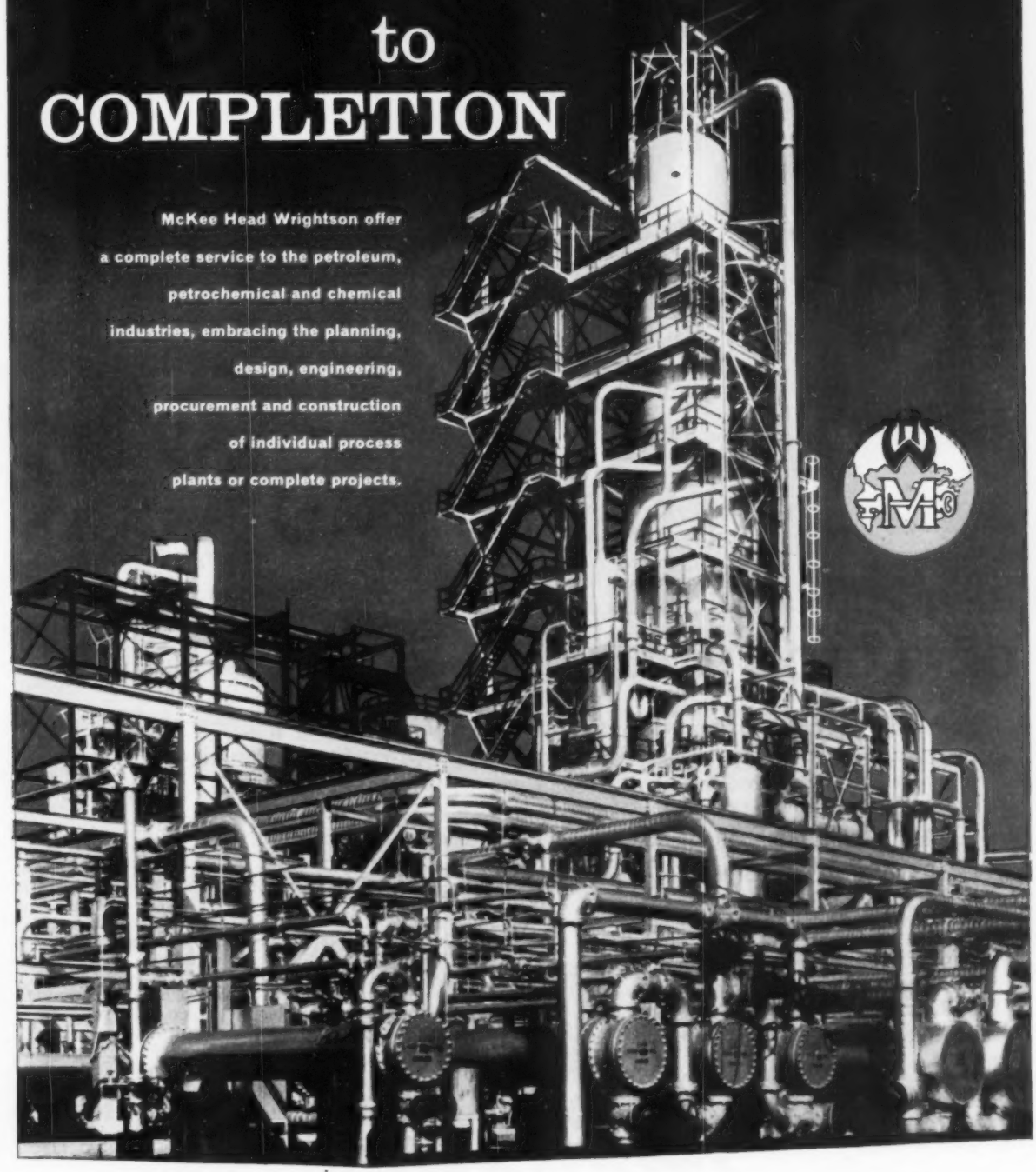

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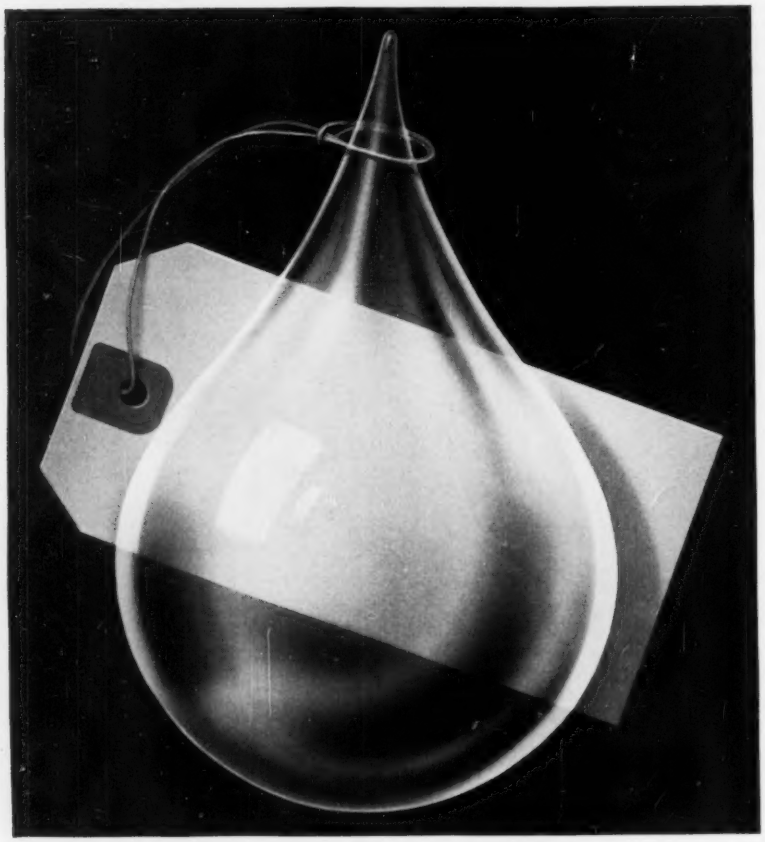

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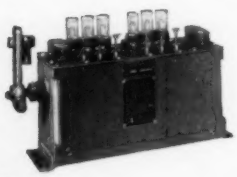

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Happenings . . .

layer of air so hot it cannot be used in cooling the engine and other internal parts.

Appleby and three other scientists from Shell's research center at Emeryville, Calif., have developed methods for producing two types of fuels from existing refinery streams, thereby making their supply practical for high-speed aircraft applications.

Fuels of the first type, the naphthenes, are made by saturating a by-product of gasoline with hydrogren. The hydrogen combines with components in the by-product and makes a petroleum-derived naphthene that is as stable as its pure counterpart. The power and other properties of the petroleum naphthenes will match most of the pure naphthenic hydrocarbons, Appleby said.

Fuels of the second type, the paraffins, offer practical advantages for certain applications, but making the paraffins will be more difficult than making naphthenes. High paraffin-content fuels made from refinery streams would cost more than refinery naphthenes, but, like naphthenes, they would be less costly than the pure variety. However, both of the new fuels will cost more than present jet fuels, Appleby added.

Experimental 'Highway' Checks Car Fuels, Lubes

Scientists at Socony Mobil Oil Co., Inc., have designed a four-lane "highway" that permits autos to "travel" up to 100 mph without moving an inch. The new "Hy-Way Simulator" is being used to test tomorrow's car fuels and lubricants. It reproduces almost every traffic and road condition the American motorist encounters, stop-and-go jams, high-speed turnpikes, and steep up-and-down grades.

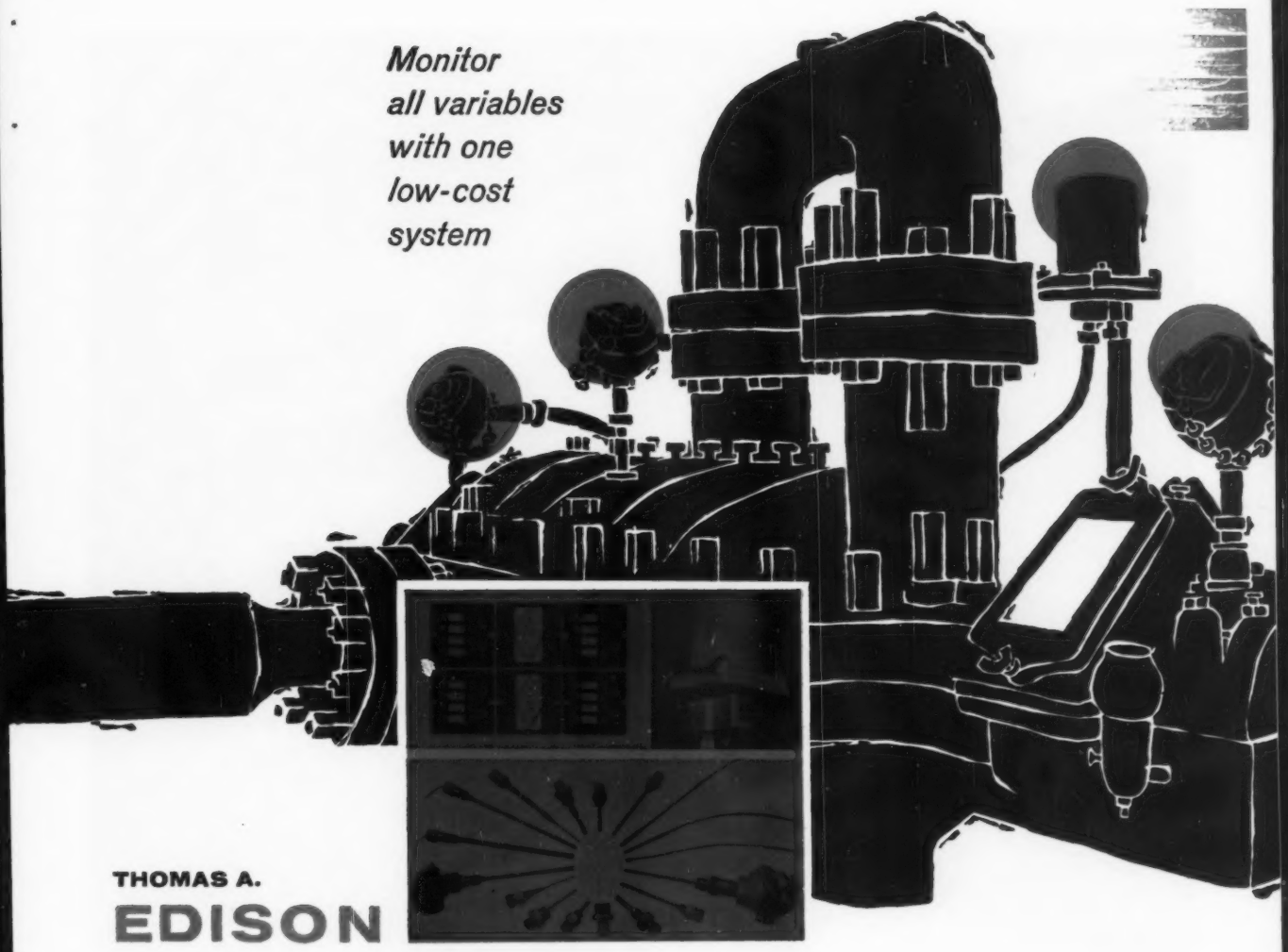
The $153,000 installation, located at Socony's Paulsboro, N. J., Research Department, is used to measure the performance of experimental gasolines and lubes, and their effect on wear and cleanliness of engines, transmissions and axles. The driverless autos operate on treadmills, reproducing a single car's actual road trip previously recorded on magnetic tape. This taped record of the original trip is played back into the vehicles on the simulator, so that identical throttle positions and speeds, as well as road grades met on the course, are duplicated.

June Crude Production Tops May By 91,000 bpd

Production of crude petroleum in the United States averaged 6,939,000 bpd in June, an increase of 91,000 bpd over the May average of 6,848,000 bpd, reports

For more data on advertised products, use Readers' Service Cards, last page.

Monitor all variables with one low-cost system



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helps you make maximum use of manpower

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Virtually all critical temperatures and pressures can be guarded with this one system: motor and pump bearing temperatures, pump case temperatures, station suction and discharge pressures, unit suction and discharge temperatures and pressures, motor winding temperatures, and in compressor stations compressor cylinder temperatures, cooling water temperatures and lube oil temperatures and pressures.

In addition to guarding against equipment failure, Omniguard assures optimum use of your equipment. Due to its accurate monitoring you can operate your equipment at maximum load with complete safety. You'll be able to handle greater capacities with less equipment. Fuel and maintenance costs will be cut.

You'll require fewer personnel for monitoring because Omniguard does an accurate job of watching critical pressures and temperatures.

In automatic operation, Omniguard is readily adapted to computer operation and permits easy transmission of digital data. The reliable performance of Omniguard makes it ideally suited for completely automatic stations. Each temperature and pressure is monitored continuously by means of individual wheatstone bridge circuits. There is no scanning—no mechanical or electronic stepping switches to wear out or require maintenance.

For complete information see your Edison Representative or write for Catalog 3036C.

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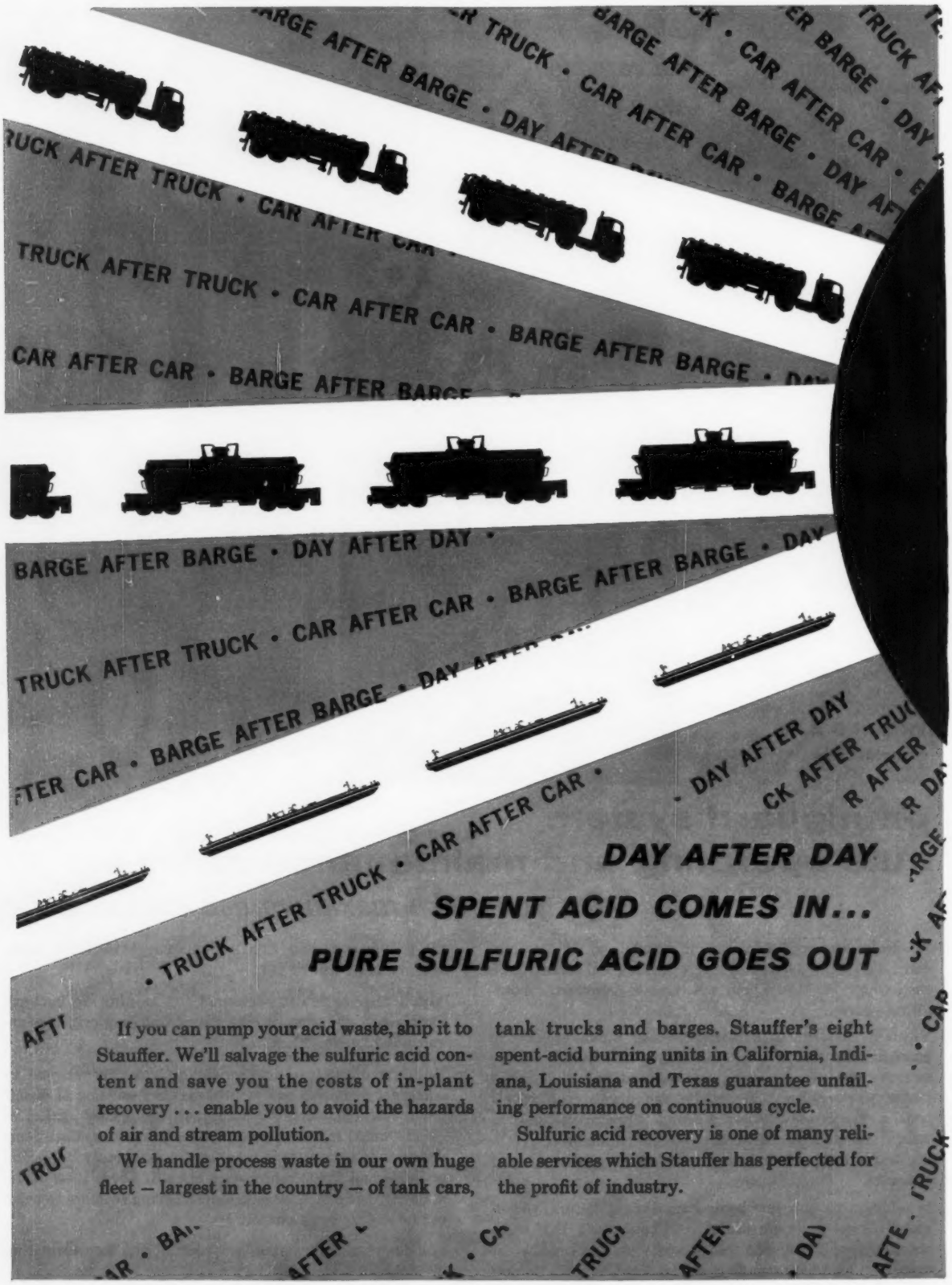
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If you can pump your acid waste, ship it to Stauffer. We'll salvage the sulfuric acid content and save you the costs of in-plant recovery . . . enable you to avoid the hazards of air and stream pollution.
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Sulfuric acid recovery is one of many reliable services which Stauffer has perfected for the profit of industry.
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Happenings . . .

the Bureau of Mines, U.S. Department of the Interior. Crude production for the first half of 1960 averaged 7,070,000 bpd, 124,000 bpd below that reported for the same period last year. Imports of crude oil for the first six months of 1960 as reported to the Bureau of Mines, averaged 1,015,000 bpd compared with 960,000 bpd in the first half of 1959.

For the first half of 1960 the indicated demand for all crude averaged 8,084,000 bpd, 16,000 bpd below total crude demand in the same period of 1959. Comparing half-year crude demand in 1960 and 1959, demand for domestic crude was down 80,000 bpd while demand for foreign crude was up 64,000 bpd. Crude stocks on June 30, 1960 totaled 257,301,000 barrels, 15,204,000 barrels below the June 30, 1959 level.

Total crude runs to stills in June averaged 8,126,000 bpd. For the first six months of 1960 and 1959, total crude runs averaged the same, 8,052,000 bpd. Comparing crude runs in the first half of 1960 with 1959, runs of domestic crude decreased 72,000 bpd and runs of foreign crude increased by the same amount.

Standard-Indiana Head Sees 'Energy Market' In Oil World

The oil industry has ahead of it "an energy market of staggering proportions," if it will learn to live with "a major problem of its own making," John E. Swearingen, president of Standard Oil Co. (Indiana), told the National Petroleum Association at the group's recent meeting in Atlantic City, N. J.

Swearingen suggested three positive actions for advancing the petroleum industry:

- Adjustment of operations to present realities.
- A slowing down of new additions to capacity so that demand can catch up.
- A stimulus to demand by all available means, creating new markets rather than waiting patiently for them to develop.

The petroleum industry must grow in new directions, he said, or slow down its growth rate until supply and demand achieve a balance.

Demand Slightly Higher For First Half of '60

Petroleum demand during the first half of 1960 averaged 10,051,000 bpd, slightly higher than had been forecast and 2.3 percent higher than the same period last year, according to IPAA reports. During the three months, June-August, demand averaged 9,350,000 bpd, an increase of 381,000 or 4.2 percent over the same months last year and 82,000 or 1 per-

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Behind this dial, Wheelco presents a *new* instrument line at industry's most attractive price . . . the Double-O Models Recording and Indicating Controllers. Wheelco has integrated the most popular and the same famous Wheelco quality features into one full-size (not a miniature) electronic potentiometer controller line. And now, a volume production savings is passed on to you. Write today for complete details.

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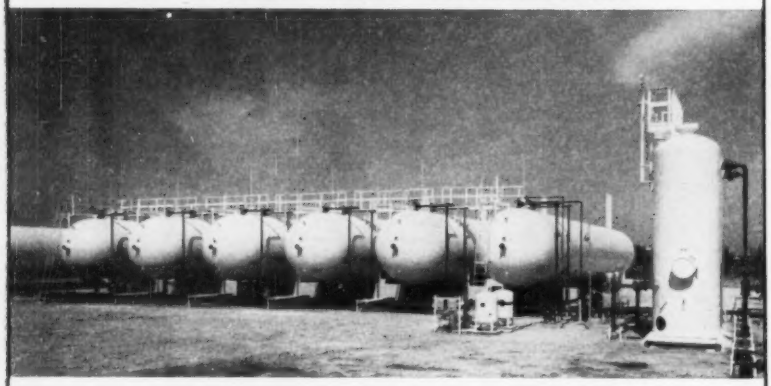

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STEEL PLATE FABRICATORS ASSOCIATION

Happenings . . .

cent higher than had been forecast by IPAA.

Outlook for total demand during the months, October-December, shows a continued trend of the last three months and an average of 10,400,000 bpd, about 400,000 bpd or 4 percent higher than the same time in 1959.

2,500 Attend Illinois Oil Industry Convention

More than 2,500 men and women from all segments of Illinois' oil industry met to hear some straight talk about businessmen's responsibilities toward government and public affairs at the Illinois Oil Industry Convention in Springfield, September 21.

Service station operators, jobbers, producers, refiners and company salesmen heard major talks by Governor Straton, Otto Kerner, John Winger, Jack Brickhouse and Willard Wilson. Winger, a top-ranked oil economist from the Chase Manhattan Bank in New York, told the convention delegates of oil's outlook for the '60's, the startling energy demand picture for oil up to 1970, and the impact on oil of regulation of the field price for gas.

The most challenging remarks made to the oil group came from Willard Wilson, former Nebraska state senator and now secretary of the American Petroleum Institute in New York. Wilson blasted businessmen who say they can't get mixed up in politics because it is "bad for business."

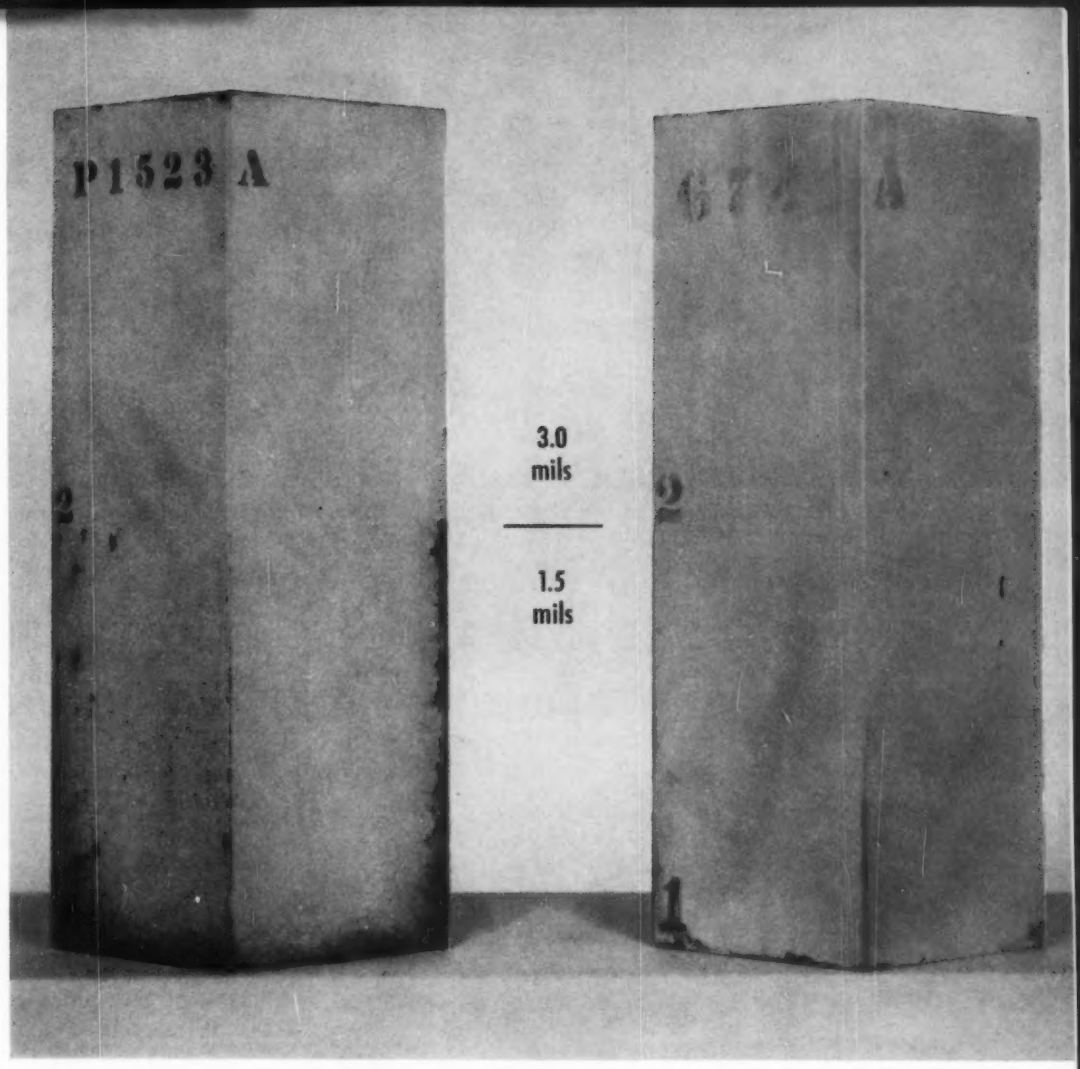
Texaco Gets $1.3 Million Contract From Air Force

A $1.3-million research contract for development of new high-energy liquid propellants has been awarded Texaco, Inc., by the U.S. Air Force. The contract calls for the development of advanced fuels and solutions for handling and storage of high-energy liquids. The research program will involve a study of all the possible sources of high-energy fuels, including the areas of oxidizers and monopropellants, according to L. C. Kemp, Jr., vice president of Texaco's Research and Technical Department.

Natural Gas Output Has 3% Increase Over '59 Period

The daily average production of natural gas liquids in June was 3 percent above June 1959, according to reports from the Bureau of Mines, U.S. Department of the Interior. The daily average production of liquefied gases at

For more data on advertised products, use Readers' Service Cards, last page.



Never before such durable protection, never before such lasting appearance in metal protective paints.

Proof anti-corrosion finish paints made with M50® pigment give unique freedom from bilging

Compare ... for color ... the gray alkyd finishes on the two exposure test angles shown above.

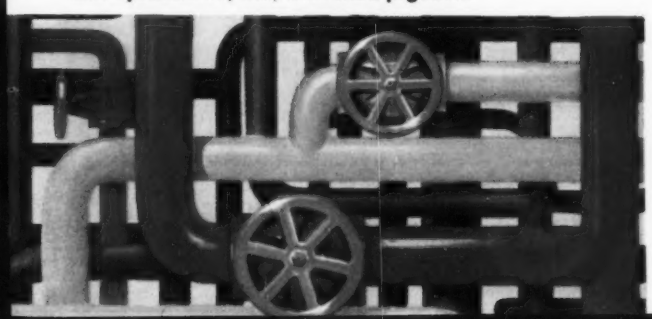
By all previous concepts for anti-corrosion paints, the one on the left should be the darker, should show some splotchiness . . . even though the paint on both angles came out of the same can. That's because the angle on the left was exposed (four years, 45°S) to the heavily sulfur-laden industrial atmosphere of Perth Amboy, N. J., while the angle on the right was exposed (four years, 45°S) only to the normal atmosphere found at National Lead's Sayville, L. I. Test Station.

As you can see, the color difference . . . bilging . . . that you might expect from SO_2-caused precipitation simply has not developed in this paint made with *M50* pigment.

Combined with its unique resistance to discoloration by the chemicals found in industrial atmospheres, fused M50 basic lead silico chromate pigment demonstrates exceptional rust inhibitive action.

Now, with *M50* pigment, your regular paint suppliers can provide standard or deep-coat anti-corrosion primers, intermediates and finishes with superior rust inhibition, superior weather resistance, and excellent tintability. Paints that are more durable and don't bilge. The *M50* pigment is suitable for use with a wide variety of vehicles.

Color code paints look better longer, are more protective, too, with M50 pigment.



See, on the next page, more details... and how you can get these new, much more durable anti-corrosion paints.

M50 an oncor pigment development of

National Lead Company

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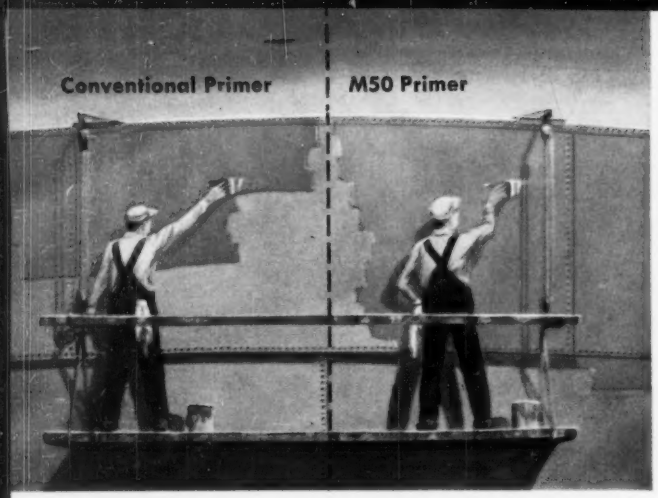
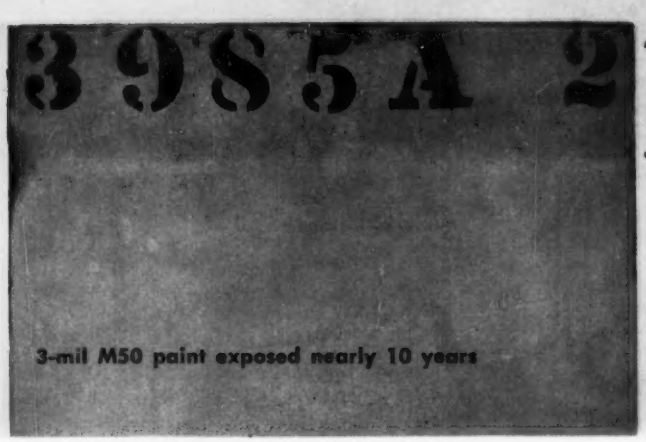


Weight for weight, anti-corrosion paints made with high-bulking M50 pigment cover 40% to 60% more steel.



Mil for mil, M50 paint films show better rust-inhibitive performance, lengthen the painting cycle interval.

Here's evidence M50 pigment paints reduce anti-corrosion maintenance painting costs two ways

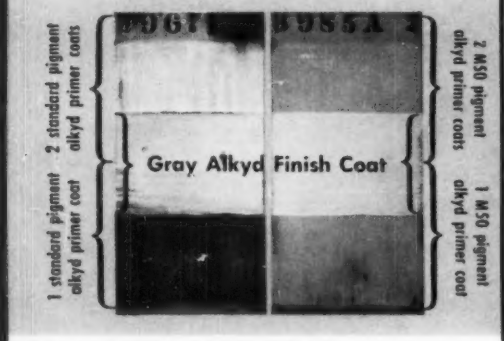
On the preceding page you have seen evidence that *M50* pigment paints are unique among anti-corrosion paints for anti-bilging properties. Exposure tests at National Lead's Sayville, L. I. Test Station have demonstrated these metal-protective paints are also unique for their anti-corrosion action, their weather-resistance, their color stability and many other performance characteristics.

Above you see evidence that *M50* pigment paints are equally unique in their ability to provide anti-corrosion maintenance painting economy. The illustration at left gives you a visual comparison between the coverage of a conventional anti-corrosion primer and an equal weight of an *M50* counterpart of this same primer (Fed. Spec. TT-P-86a, Type I). Clearly a given weight of *M50* pigment paint goes further.

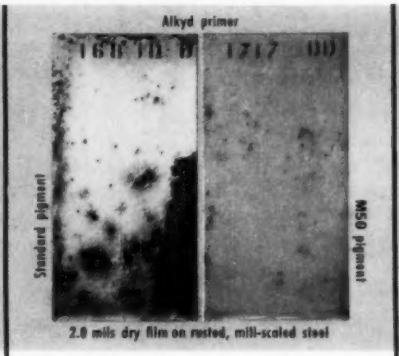
The picture at the right shows the condition of a 3-mil *M50* pigment *primer* exposed nearly 10 years *without a finish coat.* You can see that even in this severe test . . . an unprotected primer . . . anti-corrosion action is still being obtained. The repainting surface is still in good shape. Weather has not adversely affected protection. Imagine how many years of service you can anticipate from anti-corrosion *M50* finish coats applied over anti-corrosion *M50* primers in the normal or deep-coat systems!

Based on cost per sq ft per year, M50 pigment paints can greatly reduce the cost of your anti-corrosion maintenance painting.

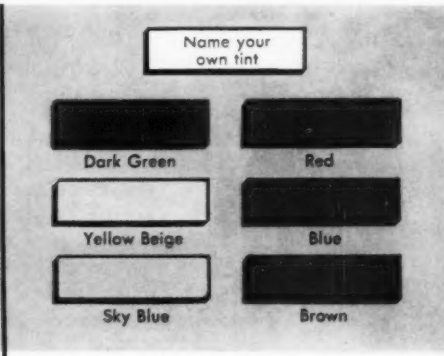
Why M50 Defense in Depth paints give anti-corrosion beyond all former concepts


2 standard pigment alkyd primer coats
1 standard pigment alkyd primer coat
Gray Alkyd Finish Coat
2 M50 pigment alkyd primer coats
1 M50 pigment alkyd primer coat

Exposed 9 years, 45°S. Each coat 1.5 mils
Proved corrosion and weather resistance



Exposed 45°S; 1 yr ind. atmos, 1 yr normal atmos.
Proved outstanding for film strength, durability



Colors above available in conventional and heavy-coat paints
A wide range of stable colors can be produced

Are you concerned with tank or structure maintenance painting in your firm? If so, you are invited: (1) to visit National Lead's Sayville, L.I. test station, where you will see the results of the 20 years research that lies behind the *M50* pigment particle and the more than 10 years of exposure testing that lies behind *M50* pigment Defense in Depth paints; (2) to send coupon below for National Lead booklet, "Defense in Depth" and typical *M50* tank paint specifications.

Next time you purchase, specify *M50* pigment paints. Any paint manufacturer can supply you.

M50 Defense in Depth

National Lead Company,
111 Broadway, New York 6, N. Y.

Gentlemen: Please send me the "Defense in Depth" booklet together with typical tank paint formulas and color chips that I can use in specifying M50-type tank paints.

Name_____ Title_____

Firm or Dept._____

Address_____

City_____ State_____

refineries was 8 million gallons, 18 percent above June 1959.

Ethane-ethylene production in June was 21 percent above June 1959. The daily average demand for liquefied gases for fuel and chemical uses decreased 5 percent from June 1959. Stocks of liquefied gases excluding ethane totaled 1,024 million gallons, an increase of 135 million gallons during June 1960. Underground stocks of liquefied gases totaled 818 million gallons, 5 million gallons greater than a year ago.

The daily average demand for natural gasoline was 11 million gallons, an increase of 7 percent from June 1959.

October Crude Estimate Near 7 Million bpd Mark

Domestic crude consumed or exported in October is estimated at 6,785,000 bpd by the Bureau of Mines, U.S. Department of Interior. Demand forecast for September was 6,980,000 bpd. July data shows total crude runs amounted to 8,260,000 bpd, including foreign runs of 1,085,000 bpd. Crude runs for August were 8,236,000 bpd including foreign runs of 1,045,000 bpd. August domestic crude demand was 7,129,000 bpd with production of 6,837,000 bpd.

Secretary Seaton Urges Oil, Gas Depletion

A retention of 27.5 percent depletion on oil and gas has been strongly urged by Secretary of the Interior Seaton. Seaton stated "that is the only sensible and realistic position" to take on the issue. Seaton further said that Vice President Nixon fully supports depletion. Two studies on oil imports have been prepared by the Department of the Interior for publication. The studies relate to the basis of imports and to asphalt.

Air Force Fuel Use Equals One-Tenth Civilian Volume

Last year 5.9 billion gallons of aviation fuel was consumed by the U.S. Air Force. This was equivalent to more than a tenth as much by volume as the total amount of gasoline and diesel fuel consumed by all automobiles and trucks in the United States in a year. This was pointed out by Col. Wilson A. Chapman, director of Air Force Petroleum and Chemicals. He noted that figures of the U.S. Bureau of Public Roads show that 56.7 billion gallons of motor fuel were consumed by the nation's 71 million motor vehicles last year.

He said that while highway consumption of motor fuel averaged 796 gallons a year per vehicle, Air Force require-

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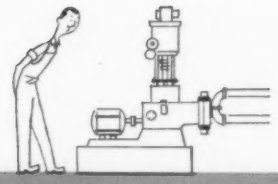
LOOK... NO HANDS!



Lapp PULSAFEEDER meters liquid flow automatically!

It's strictly hands off with automated Pulsafeeders working in your process. These dependable pumps give you *automatically* controlled metering of liquids. They do it accurately and without resort to constant level controls, high-head tanks, measuring tanks or stuffing box pumps.

Here's how it works: A pneumatic or electronic instrument senses a change in the process condition. It then sends a signal to the Pulsafeeder, which interprets the signal and corrects its pumping rate *automatically*.

When liquids must be metered in proportion to changing process conditions—*and* in heavy production service—you can depend on the Lapp Pulsafeeder . . . the *trouble-free* automatic metering pump!

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A NOTE on your letterhead will bring you Catalog 59 quickly. This new, complete, 28-page data book is chock-full of information on applications, specifications and descriptions of Pulsafeeders of a multitude of capacities and constructions. Write today . . : Lapp Insulator Co., Inc., Process Equipment Div., 1510 Poplar Street, LeRoy, New York.

For more data on advertised products, use Readers' Service Cards, last page.

RETURN LINE CORROSION *Can* BE LICKED!

Drastic reduction of return line corrosion in an easy, effective and economical way has been the unanimous experience of hundreds of plants throughout the country using Bird-Archer's Amine Treatment.

A plant in New York State, generating approximately 500,000 lb. of steam a day, had a normal condensate pH value of 6.3 that resulted in almost constant piping replacements. Only 6 lb. per day of Bird-Archer's Amine Treatment cut maintenance costs to a new low by raising the pH value to the safe range of 8.0 to 8.5.

A plant in New England, generating 600,000 lb. of steam a day, did not have an open feedwater heater which would mechanically eliminate the exceedingly high CO_2 content of their makeup water, consequently, the pH value of their condensate was sometimes as low as 5.9. Less than 12 lb. of Amine Treatment a day raises the pH value of the condensate to 8.5, eliminates excessive corrosion.

After two years of experience with Amine Treatment a power plant in Massachusetts, making 250,000 lb. of steam a day, enthusiastically reports that they eliminate over 75% of their piping replacements through the use of only 2 or 3 lb. a day of Amine Treatment.

Return line corrosion has been licked at these plants. Let a Bird-Archer Service Engineer help you solve *your* corrosion problems.

Write for Bulletin CP100 and the name of the Bird-Archer Service Engineer nearest you.

BA-803

BIRD-ARCHER
WATER TREATING CONSULTANTS
The BIRD-ARCHER Company, 4337 N. American St., Phila. 40, Pa.
New York • Chicago
The BIRD-ARCHER Co. of California, 415 Brannan St., San Francisco
Offices in Canada and Mexico

Happenings . . .

ments for aviation gasoline and jet fuel combined now average about as many gallons for every plane-hour flown.

Refining Profits Increase $3 Million Over Last Year

U.S. refiners, including integrated companies, have reported their net profits for the second quarter of 1960 at $623 million, $3 million more than in the corresponding period of 1959, the Federal Trade Commission and Securities and Exchange Commission have disclosed. Net profits for the first quarter of 1960 were $684 million. In the second quarter sales amounted to $7,924 million, an increase of $401 million from last year's second quarter. However, second quarter sales this year are down $260 million from the first quarter.

AIChE Members To Meet In Houston on October 28

Chemical engineers of the South Texas section of the American Institute of Chemical Engineers will meet October 28 at the Rice Hotel in Houston, Texas, for their fifteenth annual technical meeting. Symposiums covering saline water and pollution will be presented. A panel discussion entitled "Chemical Engineering in Latin America," and two group discussions, "Development and Administration of Company Policies" and "Engineering Registration" will also be featured at the conclave.

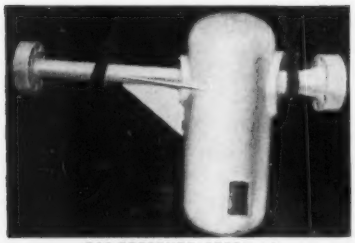
U.S. Bureau Tests Lignite For Gasification

A significant step toward gasification of American lignite, both as a future source of chemicals and as a substitute for natural gas, has been taken by the Bureau of Mines, U.S. Department of the Interior. A new pressure gasifier being developed by the bureau at its Grand Forks, N.D., Lignite Research Laboratory has made several highly satisfactory test runs, the bureau reports. The gasifier, a fixed-bed slagging type, operates on char, a partly carbonized lignite. Steam and oxygen react with the char to make product gas of good quality at high overall efficiencies.

1st Quarter Report Shows Natural Gas 16% Over 1959

Marketed production of natural gas in the first quarter of 1960 was 16 percent above a year ago, according to the Bureau of Mines, U.S. Department of

For more data on advertised products, use Readers' Service Cards, last page.



GAS PRESSURE, 1500 p.s.i.

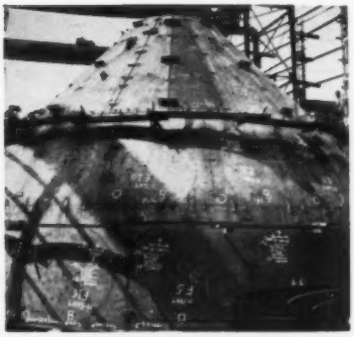
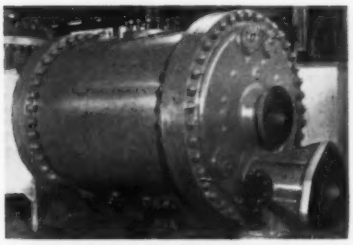


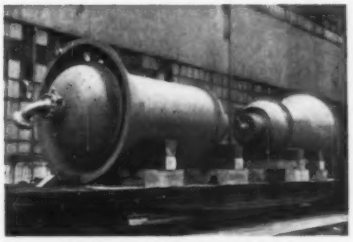
PLATE WORK, 55' dia. cone

GALVANIZING POT

SPECIAL ALLOY STEEL DEFLECTORS

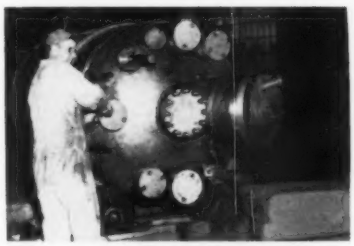


SPECIAL CHEMICAL VESSEL

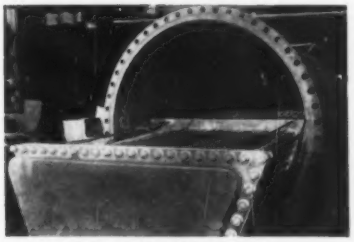


SPECIAL STAINLESS VESSELS

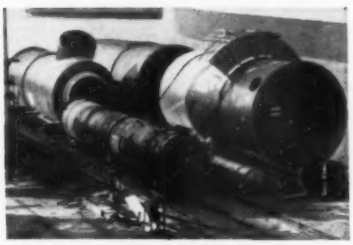
TOWER, 8'6" dia. x 154' in length



STAINLESS AUTOCLAVE



SPECIAL CONDENSER



WATER SHIPMENT

MACHINERY PARTS

MADE TO ORDER EQUIPMENT FOR OIL REFINING & CHEMICAL PLANTS

We place at your disposal one of the largest and most thoroughly equipped plants of its kind, featuring advanced production methods with experienced personnel in all departments.

PRODUCTS—Towers, Stills, Condensers—Kilns, Heat Exchangers, Pressure Vessels, Plate Work—All Codes, Any Material, Special Machinery, Machine Work.

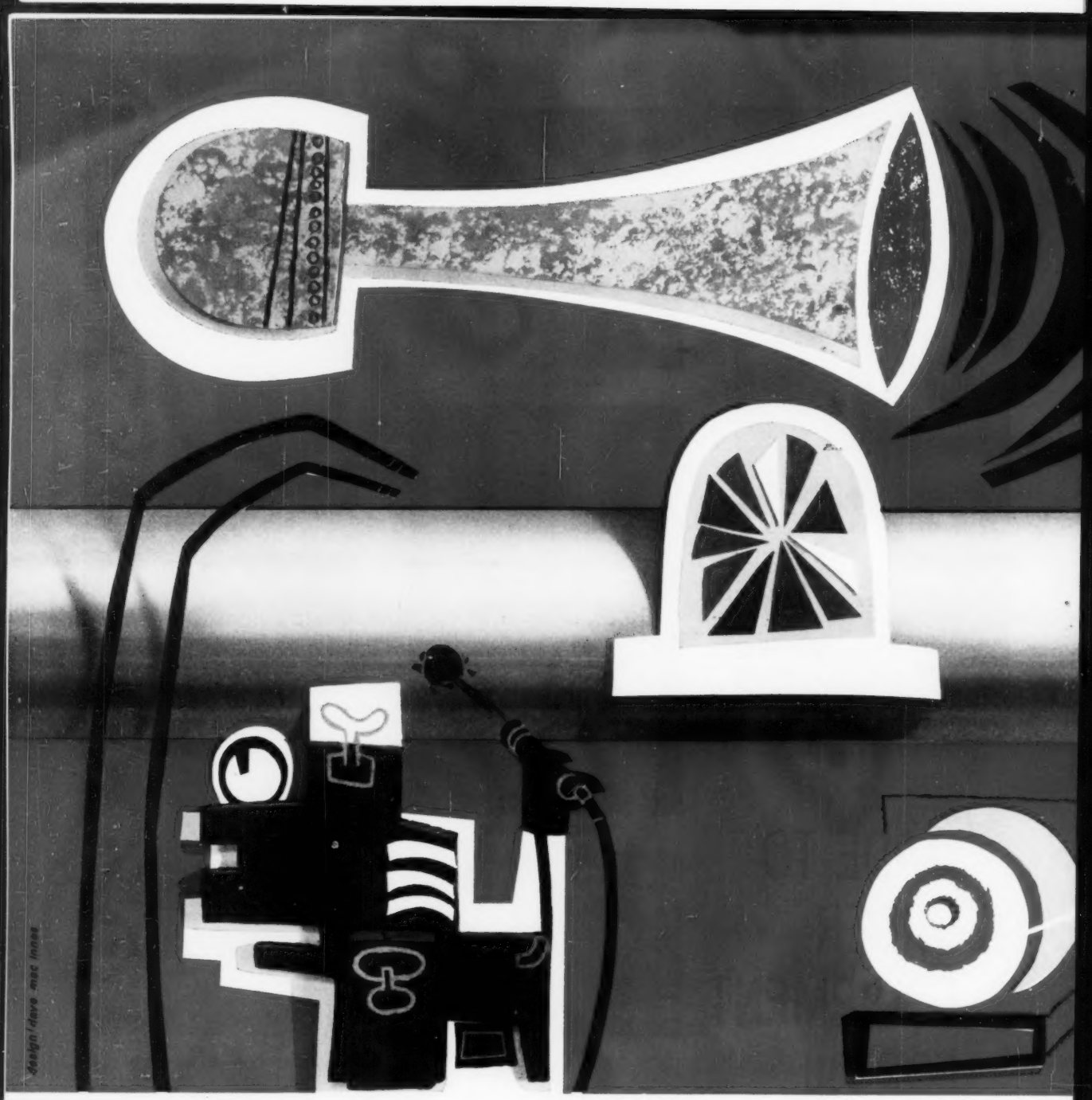
SPECIAL SERVICES—X-Ray Equipment—Stress Relieving Furnaces.

SHOPS—Boiler, Welding, Machine, Fabricating, Pipe, Blacksmith, Anglesmith, Sheet Metal, Copper, Separate Stainless Shop.

WATER AND RAIL SHIPMENTS—Our plant, including crane for loading and handling is located on the Delaware River with piers and deepwater to accommodate sea-going ships and railroad connections to all points.

SUN SHIPBUILDING & DRY DOCK COMPANY

CHESTER, PA.



Lights, camera, action

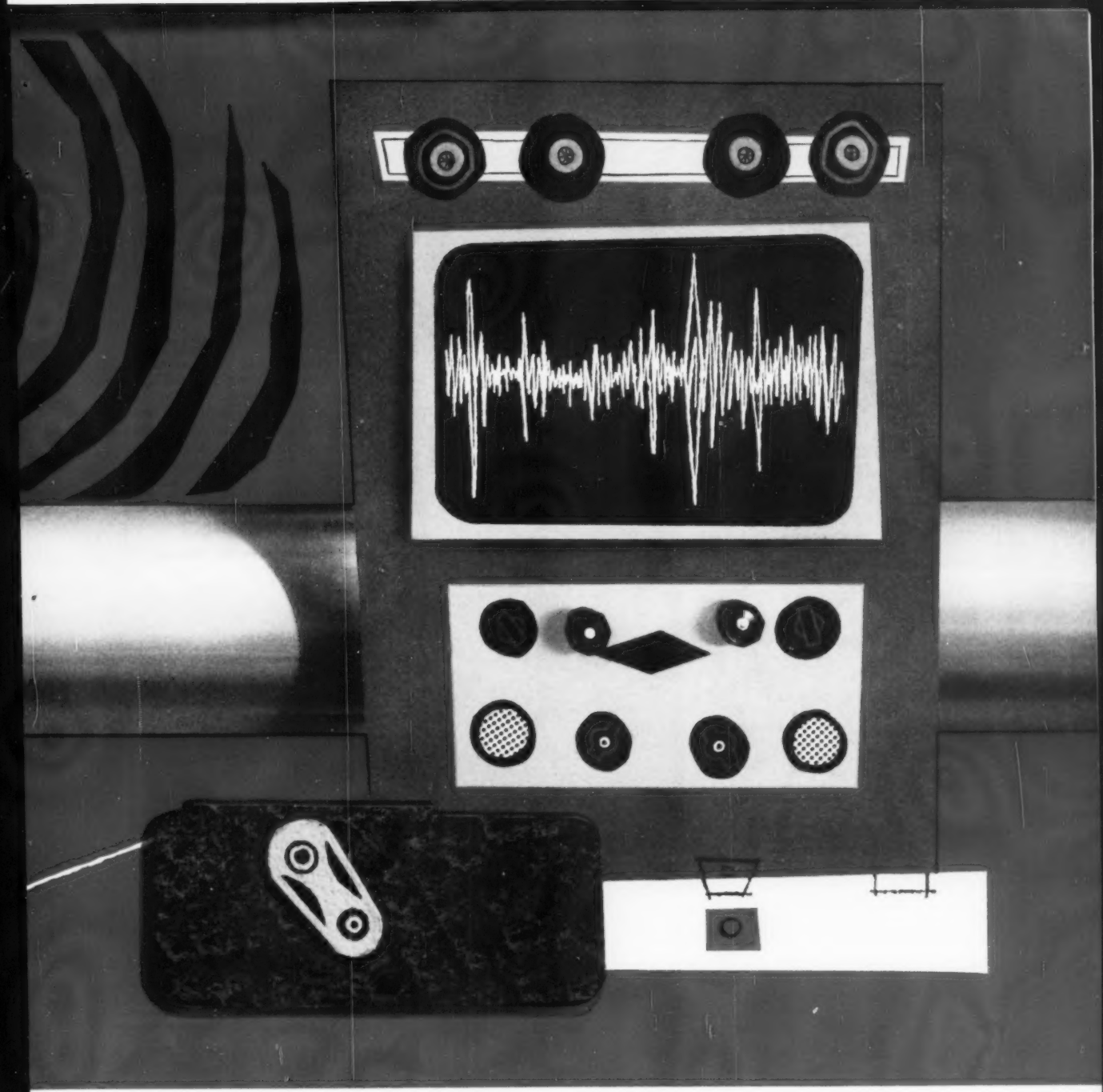
National Tube tests USS National Electric-Resistance Welded Pressure Tubing with sound waves. This ultrasonic weld inspection process is tougher than a Hollywood screen test.

This mark tells you a product is made of modern Steel.

As the tubing slides directly over a ground quartz crystal, electrical pulses are focused on the weld area. The crystal changes these pulses into ultrasonic vibrations which bounce off the weld and reflect its strength or weakness. The vibrations are speared by the crystal, converted back into electrical energy, and floated across an oscilloscope screen.

If a bad weld is reflected, the electrical current dances wildly on the screen and triggers an alarm system. The crooked pattern is pen-recorded on a graph, a bullfrog-voiced horn croaks loudly, and the tubing is squirted with black paint to mark the defect.

In case the ultrasonic unit breaks down, a red-faced dome



light automatically flashes, revolves and winks at the weld inspector. This blushing signal tells him that the unit needs to be repaired. It's added insurance that every length of tubing is completely tested before it leaves the plant.

Our inspection techniques are rigid. But they help us develop a high quality product for use in applications such as boilers, heat exchangers, condensers, superheaters, economizers and other types of heat transfer equipment. Consider USS National Electric-Welded Tubing for your next installation. Our trained Mill Service Force is available for field consultation. Write National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. © *USS and National are registered trademarks*

National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Export Company, New York
United States Steel Supply Division

ENGINEERED PRODUCTS

for Petroleum Refining

COMBAT CORROSION PROBLEMS

Garlock LATTICE-BRAID† Teflon Packings are perfect on pumps and engines in petrochemical, oil and gas service. They are strong, long-lasting, chemically inert. Withstand temperatures ranging from −120°F to +500°F. Less gland pressure is required to effect an adequate seal, resulting in longer sleeve and packing life, less downtime. Catalog AD-131.

Garlock CHEMISEAL† Mechanical Seals with Teflon* bellows possess greater immunity to corrosion than other designs. Easy to handle and install, do not score shafts, engineered to give a life expectancy many times that of other seals. Available in standard sizes to fit all pump shafts $\frac{7}{8}$" to $2\frac{1}{8}$" shaft. Seals against all media in pressures to 100 psi at 75°C or 75 psi at 100°C. Catalog AD-164.

Garlock Teflon-jacketed Gaskets give you the advantage of using Teflon without sacrificing resiliency and deformability . . . particularly important on your glass-lined process equipment, standard metal flanges, and glass pipe flanges and fittings. Garlock offers four basic designs—slit envelope, milled envelope, formed shield, double jacket—and a wide selection of filler materials and thicknesses. Catalog AD-154.

Garlock GUARDIAN† Gaskets provide a safe, positive seal against high temperatures and pressures of steam, oils, gases, liquids. Gasket density, introduced during manufacture, assures dependable sealing under varying service conditions. Used at temperatures to 1050°F, pressures to 2500 psi . . . available in round, oval, square, flat side, diamond, pear and other shapes in practically any size. Large regional warehouse stocks are maintained at Camden, Cleveland, Houston and San Francisco. Catalog AD-104.

GARLOCK

For more complete information, call your Garlock representative at one of Garlock's 26 sales offices and warehouses throughout the U.S. and Canada. Or, write Garlock Inc., Palmyra, New York.

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

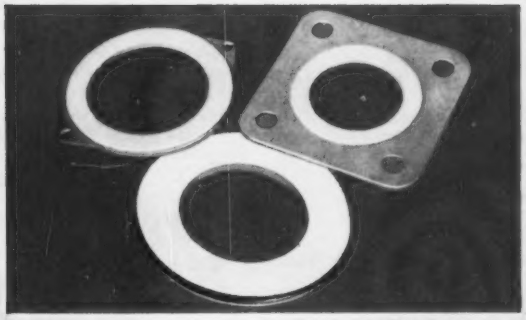
Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

†Registered Trademark
*DuPont Trademark for TFE Fluorocarbon Resin

CHEMISEAL Mechanical Seals can be installed quickly and simply, offer leak-proof sealing without shaft wear . . . resist most reactive chemicals.

GUARDIAN Gasket V-shaped metal plies have an automatic spring action that reacts to variations in compression, internal pressures, and temperature changes. Assure leak-proof seal under most severe conditions.

LATTICE-BRAID Teflon Packing lasts far beyond the limits of other packings . . . gives maximum service over wide range of temperatures, pressures. Only Garlock can give you Lattice-Braid.



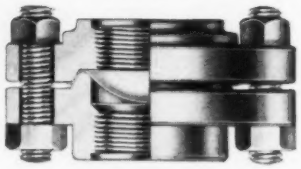
Teflon-jacketed Gaskets offer the advantage of applying Teflon without the loss of resiliency . . . ideally suited to pipes, flanges in processing.

You don't swallow this "tranquilizer"... but it can bring you priceless peace of mind! It's the rupture disc in a BS&B Safety Head—one of thousands upon thousands that protect personnel and equipment against dangerous pressure build-ups in vessels and lines containing air, gases or liquids.

When pressures rise above predetermined safe limits, this disc ruptures to provide instantaneous, unrestricted relief. BS&B designs discs to rupture at any specified pressure from 3 to 100,000 pounds per square inch. They are supplied in sizes ranging from ⅜-inch to 36 inches diameter, and in special sizes to virtually any specification.

BS&B SAFETY HEADS protect pressure systems in every type of industry

Thousands of BS&B Safety Heads have been in use for the past 26 years in virtually every type of industry where pressure protection is a problem. If your responsibility includes the *safe* operation of pressured systems in your plant, why not let us tell you more about BS&B Safety Heads?



EFFICIENCY OVER 60 YEARS BS&B RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

manufacturers of diaphragm valves, controllers, regulators, safety heads.
Dept. 2-F10
7500 East 12th St.
Kansas City 26, Mo.

Happenings . . .

the Interior. The quantities used by various classes of consumers in the first quarter increased over the same period of 1959 as follows: Residential, 6 percent; commercial, 9 percent; and industrial, 5 percent. Withdrawals from storage were 38,600 MMcf greater than in the first quarter of 1959.

Ethyl Researcher Speaks About Gasoline Additives

As many as 10 different chemical additives are added to gasoline to improve its performance in automobile engines, A. E. Felt, of Ethyl Corp.'s Detroit research laboratories, said at a national meeting of the Society of Automotive Engineers in Milwaukee. These additives impart essential properties to gasoline that would be impossible or more costly to attain by refining methods alone, he declared, in a paper co-authored by H. C. Sumner, also of the Ethyl laboratories.

The functions of gasoline additives range from preventing operating difficulties to extending engine life, Felt said, pointing to such additives as antioxidants, anti-icing agents and upper cylinder lubricants. The most widely used gasoline additive, he continued, is tetraethyl lead, which adds about 10 octane numbers to today's gasolines.

Two new antiknock agents have recently been introduced, Felt pointed out. One of them, tetramethyl lead, offers superior antiknock effectiveness in some of today's gasolines and engines. The other, a manganese compound, is a remarkably effective antiknock when used alone. But its main value stems from the fact that very small amounts markedly boost the effectiveness of the lead-based antiknocks, he explained.

- Changing Times -

Refinery crude runs of Sinclair Refining Co. for the nine months ending Sept. 30, 1960 averaged 419,000 bpd, or 11,000 bpd under the corresponding 1959 period, equivalent to a reduction of 2.6 percent.

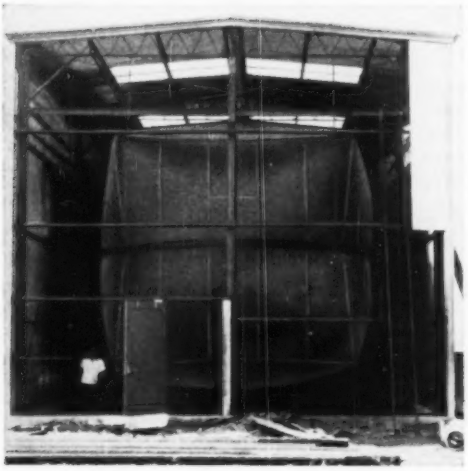
"Considerable progress" in its political action program has been made by Gulf Oil Co. according to Henry La Cossitt, public relations representative for Gulf in Washington, D.C.

Japan's crude imports requirements for the second half of the current fiscal year have been estimated at 99,313,200 barrels. The country predicts the total crude demand for the period to be 544,300 bpd, of which 9,000 bpd would be domestic.

Caltex will put its refining, marketing and marine transport activities in France into the company set up under the name

For more data on advertised products, use Readers' Service Cards, last page.

BIG SAVINGS WITH LOW-COST REEVES-VULCAN BREATHER BALLOONS



Stop vapor loss with this air-tight, self-contained, completely closed system.

Now—with a low-cost Breather Balloon installed in new or modified storage systems, you can capture the vapors that might otherwise be lost during the storage or transfer of volatile liquids. Reeves-Vulcan Breather Balloons require no skilled labor to install, no high priced housing . . . cost practically nothing to maintain.

Ultra-high strength neoprene-coated nylon gives these rugged balloons unusually long life. Every Breather Balloon installed is still in use, still returning profits. Make your storage tank a closed system . . . install Reeves-Vulcan Breather Balloons—the most efficient and most economical system of vapor conservation ever developed for low to medium storage volume.

For free, informative brochure, write to: Reeves Brothers, Inc., Vulcan Rubber Products Division, 1071 Avenue of the Americas, New York 18, New York.

REEVES VULCAN

Reeves Brothers, Inc., Vulcan Rubber Products Division
1071 Avenue of the Americas • New York 18, New York

SAVE! SAVE!

From $25 to $450 a year on Oil Alone . . . with a RIDGID!

How much oil do you use each day threading pipe, rod or conduit by hand or power drive?

One-half pint? One gallon? If it winds up on the floor, you're spending somewhere between $25 and $450 a year just for the privilege of cleaning up oil.

The RIDGID saves that money for you . . . lets you use all the oil you should!

- **Ends Oil Waste and Messy Floors**—Costly oil is double screened and re-used again and again.
- **Lengthens Die Life**—Well oiled dies last longer, stay sharper . . . gives cleaner threads for fast, easy installation.

The easy-to-carry RIDGID comes complete with a screened chip pan, circulating oil reservoir and hose-connected hand pump-gun. See it . . . buy it at your local Supply House. You'll be glad you did!

Costs Only $23.20

with 2 gallons of RIDGID Thread Cutting Oil!

RIDGID Dark and Nu-Clear Thread Cutting Oils are available in convenient (4 ounce Nu-Clear only), 1 quart, 1 gallon, (2 gallon Nu-Clear only), 5 gallon, 30 gallon and 55 gallon containers.

RIDGID

The Ridge Tool Company • Elyria, Ohio, U.S.A.

For more data on advertised products, use Readers' Service Cards, last page.

Tightly sealed against heat, cold, dust, fumes, rain, snow . . .

ELLIOTT

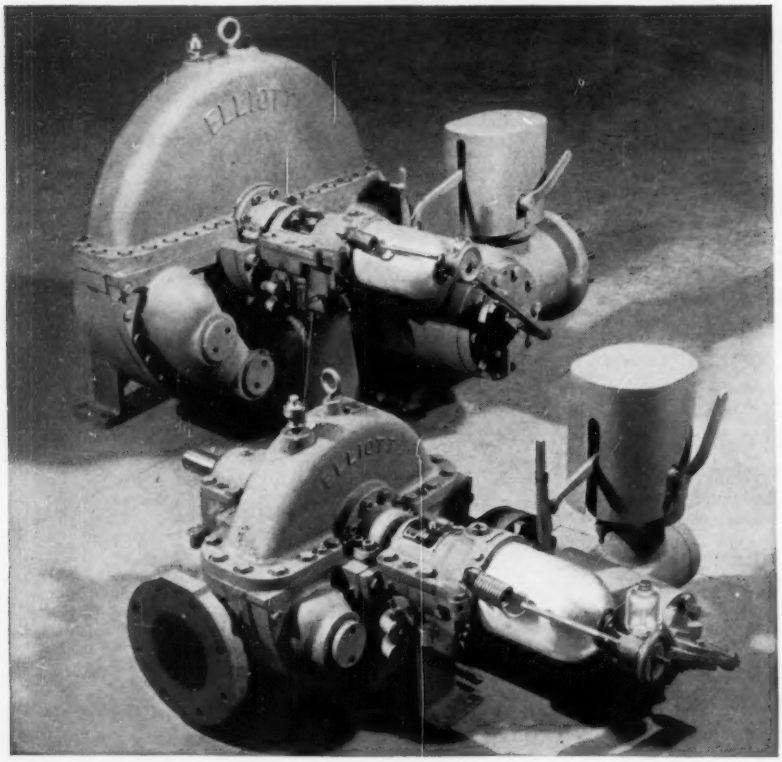
Mechanical Drive Turbines are dependable, economical

Strong and husky, Elliott type YR turbines make dependable, economical drives for pumps, compressors, fans, line shafts, generators and other equipment. All-weather protection assures dependable operation under all conditions of heat, cold, moisture, dust and contaminated atmosphere.

The governor is simple and reliable, and is available in several modifications to match speed and pressure control requirements. YR turbines are designed for easy installation and service. Many key parts are interchangeable for various frame sizes. Two sizes are shown below. Write for descriptive bulletin H 22-D. HO-3

ELLIOTT Company
Jeannette, Penna.

In addition to the units illustrated here, Elliott makes single-stage turbines in special frames, reduction gears, multistage mechanical drive turbines to 50,000 hp, and turbine-generators through 44 mw.



Changing Times (continued)

Union Industrielle des Petroles. Caltex holds 40 percent of the company, while French government-controlled producers own the rest.

Negotiations are in progress toward the acquisition by Humble Oil & Refining Co. of the assets of Monterey Oil Co.

A joint company in The Netherlands has been formed by Bataafse Petroleum Maatschappij N.V. and Montecatini Co. Gen. per l'Industria Mineraria e Chimica to build and operate a polypropylene plant in Rotterdam.

Thirteen Atomic Energy Commission studies in the fields of health and safety have been released for sale to the public through the Office of Technical Services, Business and Defense Services Administration, U.S. Department of Commerce, Washington, D. C.

Prizes totaling $1250 have been awarded college students in contest in colloid and surface chemistry at University of Southern California. The contest was sponsored by Continental Oil Co.

A merger of Federal Chemical Co., Inc., and National Distillers and Chemical Corp. has been approved by both companies' boards. National Distillers will offer eight shares of its common stock for each outstanding share of Federal Chemical common stock and four common shares for each Federal preferred share.

Crude runs to refineries east of Rocky Mountains were reduced by Phillips Petroleum Co. by 7,000 bpd during August compared to July, bringing runs 12 percent below those for August 1959. An 8,000-bpd reduction is scheduled for September.

An agreement has been entered into, which, if approved by stockholders, will result in sale of all Anderson-Prichard Oil Corp. assets. Anderson-Prichard will receive $123,300,000 for its properties. Among the assets are two refineries—at Arkansas City, Kan., and Cyril, Okla.

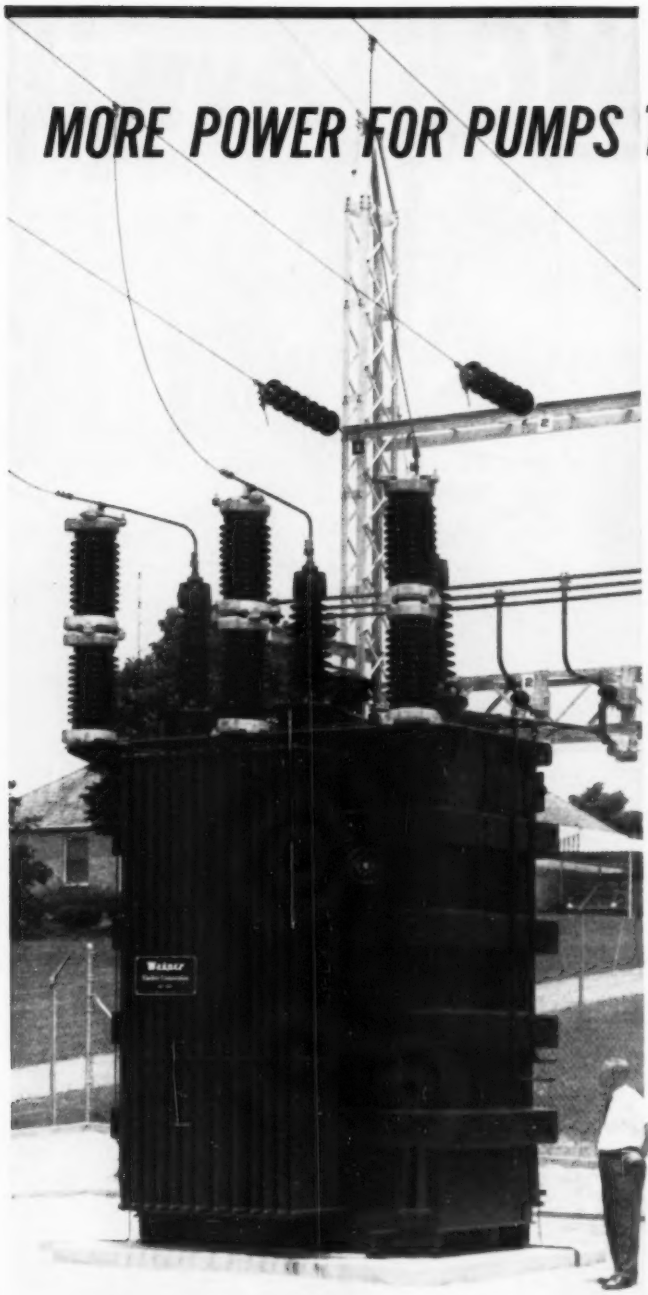
More than $400,000 has been contributed by The Ohio Oil Co. to education and support of community health, welfare and youth programs for 1960. Contributions is given chiefly through The Ohio Oil Co. Foundation.

Two $500 college scholarships have been awarded Gerald Lee Shannon and Penelope Marlin, children of Delhi-Taylor Oil Corp. employes. Delhi awards two $500 scholarships each year to employes' children who plan to enter college.

A $500 scholarship in petroleum engineering has been created at Pennsylvania State University. Known as the Drake Scholarship. it will be awarded through the university's College of Mineral Industries to a freshman in the 1960-61 college year.

For more data on advertised products, use Readers' Service Cards, last page.

MORE POWER FOR PUMPS THAT PUSH PETROLEUM



THIS WAGNER TRANSFORMER

POWERS-UP

PLANTATION PIPELINE

The Plantation Pipeline Company pumping station at Neese, Georgia, is part of an underground transportation system that pushes high quantities of petroleum products to their market.

The Neese operation was originally served with power from a 44 kv system substation. However, the size of the pumping load—which includes some 1800 hp motors—became too great for the substation to handle adequately.

To better serve the load, Georgia Power Company recently installed a 110 kv line and built a new substation. Wagner Electric Corporation furnished the transformer rated at 7500 Kva for this purpose. Today, Plantation Pipeline pumps with full power.

Now, what about your power needs? If they present a critical (or even a potential problem), call your nearby Wagner Sales Engineer. He'll help you plan your power program . . . suggest Wagner transformers that will meet your needs for years to come. There are Wagner branches in 32 principal cities.

Wagner Electric Corporation

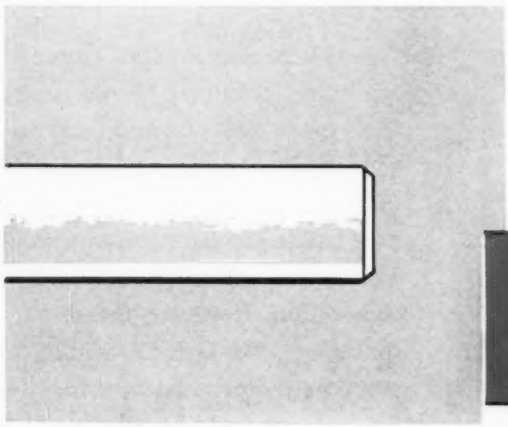
6458 PLYMOUTH AVENUE,
ST. LOUIS 33, MISSOURI

WT60-8

SERVING 2 GREAT GROWTH INDUSTRIES—*ELECTRICAL • AUTOMOTIVE*

For more data on advertised products, use Readers' Service Cards, last page.

PLANNING ...with



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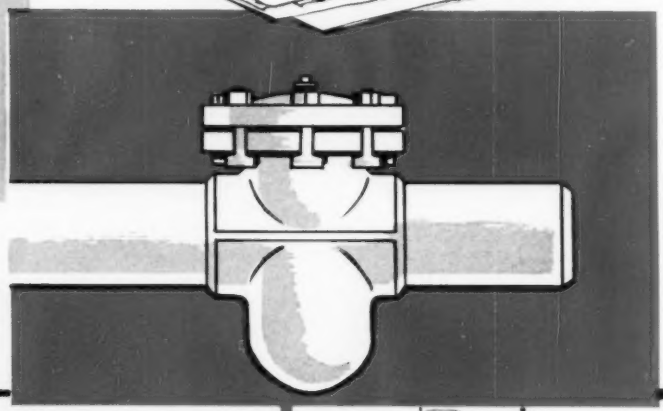
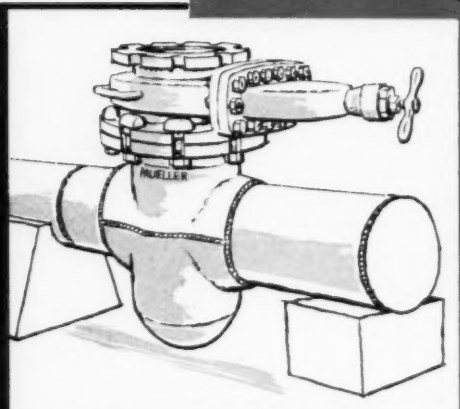


...but this!

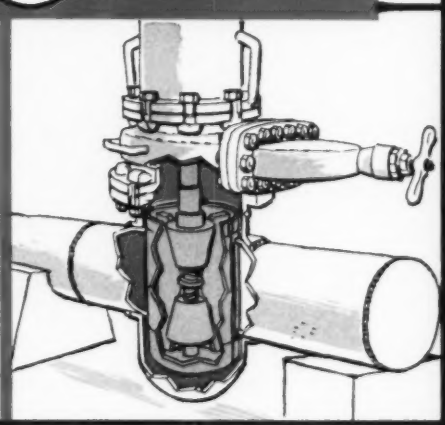
MUELLER®

NO-BLO®

METHOD



Remove cap from fitting and install gate valve.



Attach line-stopping equipment, remove completion plug, and insert neoprene covered, expanding stopper. (No drilling required)

For complete information on these and other fittings, planned with an eye to the future, write . . .

an eye to the FUTURE

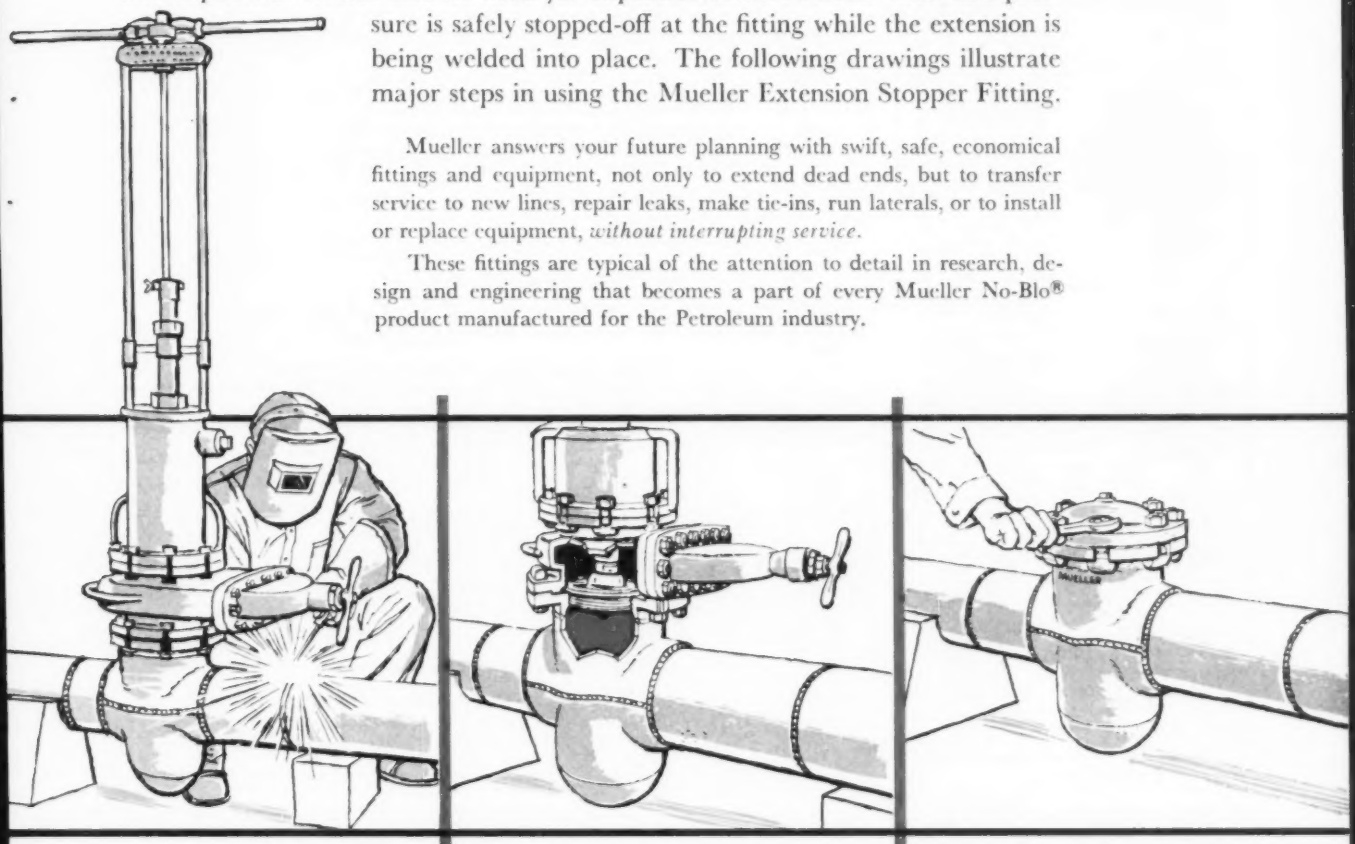
MUELLER®

Extension Stopper Fittings

■ Refinery, oil field, *anywhere* that future system expansion is likely, cap all dead ends with Mueller Extension Stopper Fittings at the time the pipe is installed. When the line is to be extended, Mueller fittings save time and money with no *interruption* of *service* and *no need for expensive control valves.* Flow line pressure is safely stopped-off at the fitting while the extension is being welded into place. The following drawings illustrate major steps in using the Mueller Extension Stopper Fitting.

Mueller answers your future planning with swift, safe, economical fittings and equipment, not only to extend dead ends, but to transfer service to new lines, repair leaks, make tie-ins, run laterals, or to install or replace equipment, *without interrupting service.*

These fittings are typical of the attention to detail in research, design and engineering that becomes a part of every Mueller No-Blo® product manufactured for the Petroleum industry.



Cut off capped end of line and weld new line to fitting.

Raise stopper and replace completion plug in top of fitting.

Remove line-stopping equipment and Gate Valve then bolt completion cap in place.

MUELLER CO. Since 1857 SERVING the Water and Gas Industries QUALITY

5522

MUELLER CO.
DECATUR, ILL.

Factories at: Decatur, Chattanooga, Los Angeles
In Canada: Mueller, Limited; Sarnia, Ontario

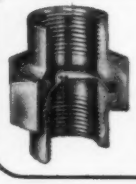
For more data on advertised products, use Readers' Service Cards. last page.

Catawissa
PERFECT SEAL
Unions

HOT FORGED from solid, rectangular steel bars, designed and produced for dependable, long-life service under the severest piping conditions!

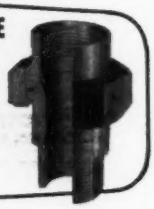
A TYPE FOR EVERY USE!
FOR ALL PRESSURES!
FOR ALL TEMPERATURES!

Standard & Double Extra Heavy
UNIONS
Available with screwed or socket weld ends. 3000-lb. sizes 1/8" to 3"; 6000-lb. sizes 1/8" to 2".

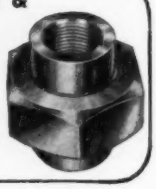


GASKETLESS
CUP-ORIFICE UNIONS
Choice of stainless or carbon steel cup-type plate. 3000-lb. service.

MALE & FEMALE UNIONS
With steel-to-steel, bronze-to-steel, stainless steel-to-steel or orifice seats. 3000-lb. service only.



FULL STAINLESS & FULL ALLOY STEEL UNIONS
With screwed or socket weld ends. 3000-lb. and 8000-lb. service.



WRITE FOR CATALOG 60
Showing the Complete Catawissa line of Perfect Seal Products

CATAWISSA VALVE & FITTINGS COMPANY
CATAWISSA, PENNA.

Meetings Calendar

Oct.	
17–19	**American Oil Chemists' Society,** Fall Meeting, Hotel New Yorker, New York.
17–19	**American Society of Mechanical Engineers,** Lubrication Conference, Statler Hilton Hotel, Boston, Mass.
17–21	**National Safety Council,** Annual Meeting, Conrad Hilton Hotel, Chicago.
–18	**American Society of Safety Engineers,** Annual Meeting, Chicago.
19–20	**National Association of Corrosion Engineers,** Conference, North Central Region, Pfister Hotel, Milwaukee.
20–21	**Gas Compressor Engine Short Course,** University of Oklahoma, Norman, Oklahoma.
20–21	**Air Pollution Control Association,** (West Coast Section), Technical Meeting, Santa Barbara Biltmore Hotel, Santa Barbara, Calif.
24–25	**ASME,** Fuels Conference, Daniel Boone Hotel, Charleston, W. Va.
25–28	**NACE,** South Central Region Conference, Mayo Hotel, Tulsa.
26–27	**Western Petroleum Refiners' Association,** Question and Answer Session on Refining Technology, Rufus Garrett Hotel, El Dorado, Ark.
–28	**Natural Gasoline Association of America,** Southern Regional Meeting, Carlton Hotel, Tyler, Texas.
–28	**American Institute of Chemical Engineers,** South Texas Section Technical Meeting, Rice Hotel, Houston.
31–Nov. 2	**ISA, AIEE, IRE,** Conference, Electrical Techniques in Medicine and Biology.
31–Nov. 2	**National Lubricating Grease Institute,** Annual Meeting, Edgewater Beach Hotel, Chicago
31–Nov. 2	**Society of Rheology,** Annual Meeting, Mellon Institute, Pittsburgh, Pa.
Nov.	
– 7	**Society of Plastics Engineers,** Regional Technical Conference, King Edward Sheraton Hotel, Toronto, Ont.
14–16	**American Petroleum Institute,** Annual Meeting, Conrad Hilton, Palmer House, and Congress Hotels, Chicago.
–18	**NGAA,** Panhandle-Plains Regional Meeting, Herring Hotel, Amarillo, Texas.
–18	**Society of Plastics Engineers,** Regional Technical Conference, Essex House, Newark, N.J.
21–22	**American Institute of Mechanical Engineers,** Gulf Coast Section Society of Petroleum Engineers, Formation Evaluation Symposium, University of Houston, Houston, Texas.
27–Dec. 2	**ASME,** Annual Meeting, Statler Hilton Hotel, New York.
Dec.	
4– 7	**AIChE** Meeting, Hotel Statler, Washington.
7–11	**NACE,** University of Illinois Corrosion Control Short Course, Urbana Campus.
12–14	**U.S. Public Health Service,** National Conference on Water Pollution, Sheraton Park Hotel, Washington, D.C.
Jan. 1961	
16–19	**ISA,** Conference & Exhibit, Winter Instrument-Automation, Sheraton-Jefferson Hotel, Kiel Auditorium, St. Louis, Mo.
–20	**NGAA,** Gulf Coast Regional Meeting, Robert Driscoll Hotel, Corpus Christi, Texas.
23–Feb. 2	**Engineering and Management Course,** University of California, Los Angeles, Calif.
Feb.	
7– 8	**Advanced Petroleum Engineer Seminar,** University of Oklahoma, Norman, Okla.
13–15	**American Industrial Writing Institute,** Western Industrial Writing Institute, Los Angeles Statler-Hilton Hotel, Los Angeles, Calif.
–24	**NGAA,** South Louisiana Regional Meeting, Lafayette Petroleum Club, Lafayette, La.
26–Mar. 1	**AIChE,** Petrochemical and Refining Exposition, Municipal Auditorium, New Orleans, La.
Mar.	
–11	**AIChE, American Chemical Society,** Joint Technical Meeting, Lamar State College, Beaumont, Texas.
13–17	**NACE,** Annual Meeting & Corrosion Show, Hotel Statler, Buffalo, N.Y.
15–17	**NGAA,** Annual Convention, The Baker Hotel, Dallas, Texas.
21–30	**ACS,** National Meeting, St. Louis, Mo.
27–31	**ISA,** Symposium on Temperature—Its Measurement and Control in Science and Industry, Veterans' Memorial Auditorium, Columbus, Ohio.
28–29	**Gas Conditioning Course,** University of Oklahoma, Norman, Okla.
April	
10–14	**Safety Engineering Course,** University of Oklahoma, Norman, Okla.
17–19	**ISA,** National Symposium on Instrumental Methods of Analysis, Shamrock-Hilton Hotel, Houston, Texas.
18–20	**American Welding Society,** Meeting and Show, Commodore Hotel, New York.

For more data on advertised products, use Readers' Service Cards, last page.

Men In Industry...

Robert E. Howe has been named executive vice president and coordinator,

Howe

Ischie

Cooper

petrochemicals and research, Sinclair Refining Co. **W. Vaughn Ischie** has been appointed executive vice president and director of manufacturing. **R. M. Cooper** has been elected a vice president and director and general manager of refineries for Sinclair. Howe and Ischie were formerly vice presidents of their respective departments.

Herbert H. Olfe has been named chief engineer, Tellepsen Petro-Chem Constructors, Houston. Olfe succeeds **H. K. McLaughlin** as head of the Engineering Department. Olfe graduated from the University of Missouri. After seven years with Shell Oil Co. at Wood River, Ill., he joined Southern Acid and Sulphur Co., St. Louis, as chief engineer. He joined Tellepsen in 1957.

John H. Johnsen, formerly manager, Standard Oil Co. (Indiana) refinery, Neodesha, Kan., has been named manager of the Wood River, Ill., refinery. Johnsen succeeds **Louis H. Butterworth,** refinery manager since 1956, who is being transferred to a special assignment in the Manufacturing Department, Chicago. Butterworth will become manager of refineries for American Oil Co. in the corporate reorganization of Standard Oil Co. (Indiana) planned for Jan. 1, 1961. Johnsen joined Standard Oil in 1945 as a design engineer at the Whiting, Ind., refinery. He became assistant head engineer in the Oils Design Department in 1947, and head engineer in the Service Department in 1959. Two years later he was promoted to assistant superintendent, Mechanical Division, Whiting refinery. In 1953 he was made an assistant manager of the Sugar Creek, Mo., refinery. He became manager of the Neodesha refinery in 1959. Butterworth joined Standard Oil's Research Department at Whiting in 1937.

Dr. Alfred Saffer and Paul S. Monroe have been elected vice presidents, manufacturing and construction, respectively, of Scientific Design Co., Inc. Saffer will be in charge of direction and expansion of the manufacturing activities of SD and other companies in the SD group, including Catalyst Development Corp. He was formerly assistant vice president, research and development. Monroe was previously assistant vice president and director of general engineering.

Urban H. Wagner has been appointed manager, Refining Coordination Division's Technical Services Department, Standard-Vacuum Oil Co. Wagner began his career with Magnolia Petroleum Co. in 1939, shortly after his graduation from Rice University, where he obtained a B.S. degree in chemical engineering. He joined Stanvac in 1952. He has served as refinery manager for three years at Stanvac's Durban, South Africa, refinery.

Edwin L. Gidley has been elected vice president and secretary of The M.

Gidley

Norton

W. Kellogg Co. **Sidney J. Norton** has been named general counsel and assistant secretary. Gidley joined M. W. Kellogg as general counsel in 1942. Norton came to the company in 1947 as an attorney.

John F. Harron has been appointed to the Advanced Management and Methods Division, Sun Oil Co.'s Manufacturing Department. He will replace **Paul D. Barton** as director of the divi-

PUTNAM

FULL PORT Ball Valves

SPECIFY - - -

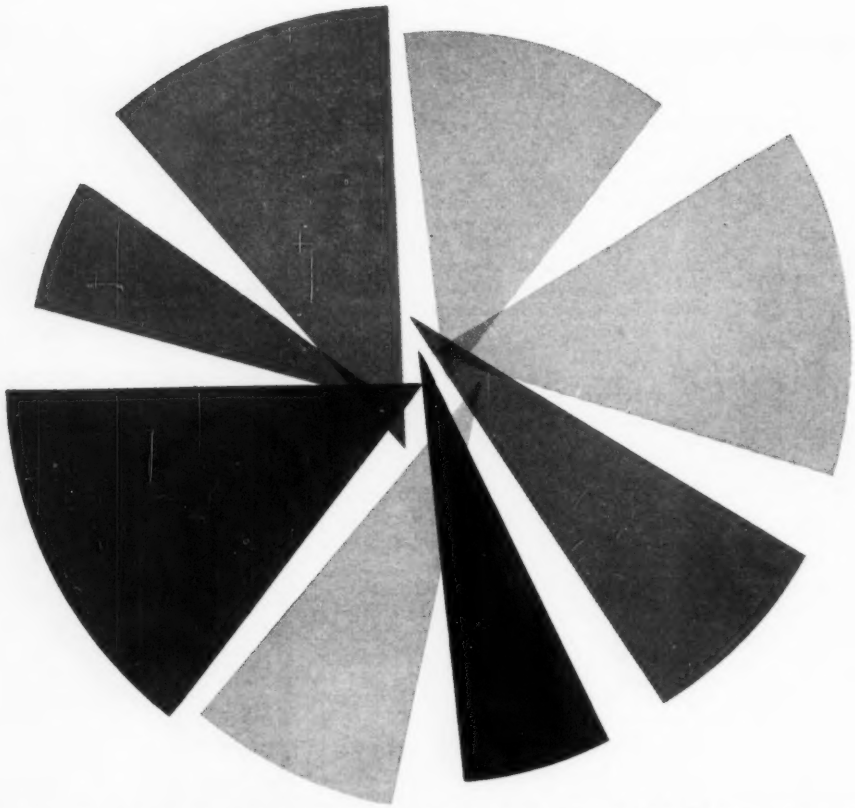
for lower piping system cost— higher efficiency

We'll be glad to tell you more, write

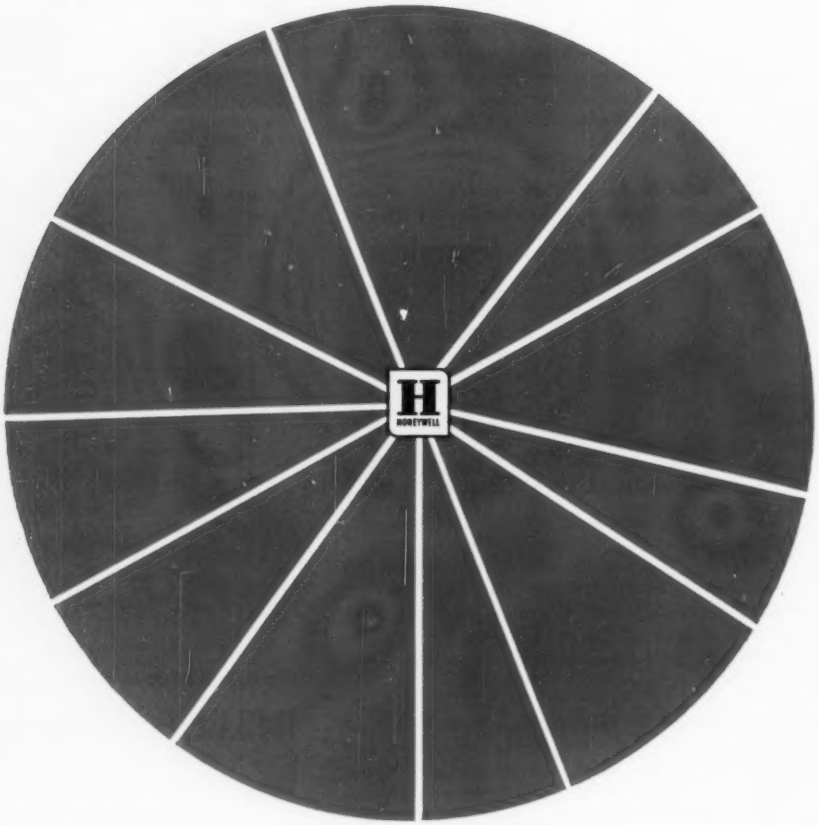
The J. L. Putnam Company, Inc.

SMITH STREET

BIDDEFORD, MAINE



YOUR PLANT'S CONTROL SYSTEM—HYBRID OR HONEYWELL?



For more data on advertised products, use Readers' Service Cards, last page.

The answer can be important to you. True, you can combine several makes of instruments into a system and get adequate results. But you usually pay a penalty for hybrid systems. There's the burden of responsibility for engineering and maintaining the system. There's the question of whether it will do what you want it to. There's the problem of modifying various makes of components to work together. And there's the inconvenience of buying instruments and spare parts from several suppliers instead of one.

Single-Source Responsibility. You avoid all of this with an all-Honeywell data processing or automatic control system. All components, from primary measuring elements to final controls, are supplied by Honeywell. If your requirements call for an analog or digital computer, Honeywell can supply it. From our systems engineers you get the advantage of experience gathered over 75 years of measurement and control work in scientific, military and industrial operations. And Honeywell takes full responsibility for the system, from initial planning through installation and startup, and even including maintenance.

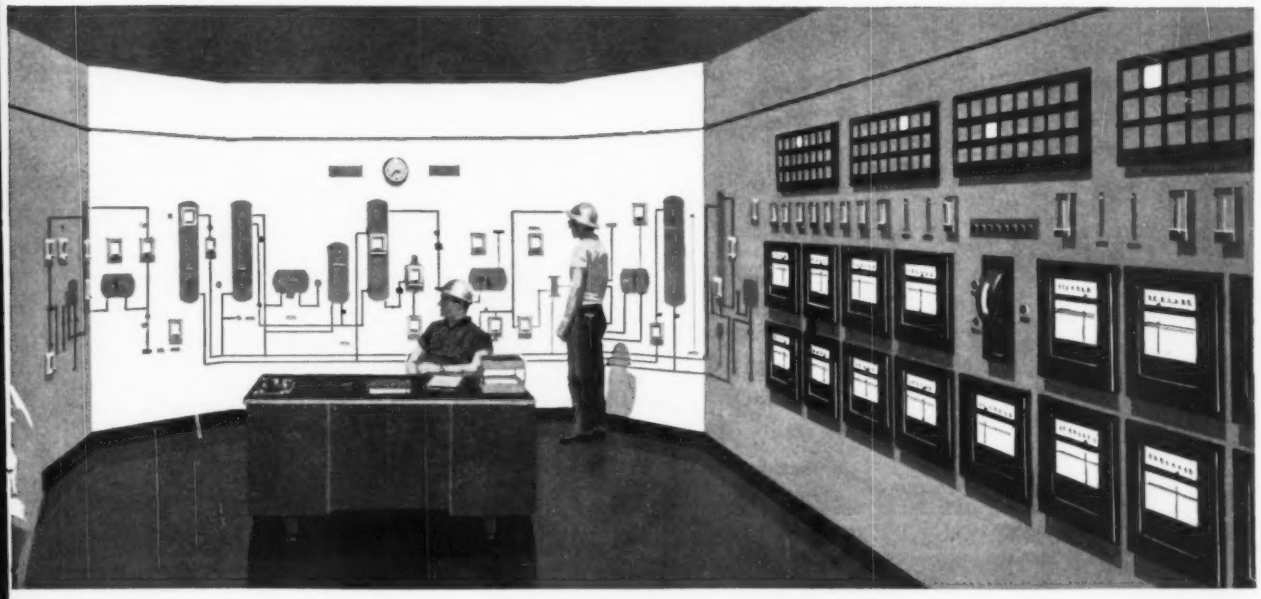
Conserve Your Working Capital. You can conserve working capital by leasing a Honeywell system from one to five years, paying for it as you use it. Because you lease at today's prices, you're protected against possible future price increases. Because you deal *only* with Honeywell, you needn't worry about long negotiations with third parties.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

75th YEAR
PIONEERING THE FUTURE

Honeywell

H HONEYWELL *First in Control*
SINCE 1885



For more data on advertised products, use Readers' Service Cards, last page.

Men . . .

sion when Barton retires. Harron has been manager of Sun Oil's refinery at Toledo, Ohio, since January 1956. He graduated from the University of Pennsylvania, receiving his B.S. degree in chemical engineering in 1926. He started his career with Sun in June 1928 as a chemical engineer at Marcus Hook, Pa.

Robert J. Anderson has been named refinery manager for Standard-Vacuum Oil Co.'s new refinery to be constructed at Adelaide, South Australia. Anderson, who holds two B.S. degrees, began his oil industry career with Esso Petroleum Co. in 1945 at the Bayway refinery. He joined Stanvac in 1952, and was appointed refinery manager at Altona, Australia, in 1957.

W. W. Clark, Houston, has been promoted to special assistant to the general manager, Continental Oil Co.'s Petrochemical Department and also will serve as assistant to the chairman of the board of Carlon Products, Inc., Aurora, Ohio, a Conoco affiliate. Clark joined Conoco in Houston in 1951 as an analyst in the Coordinating and Planning Department.

ARCCO
ARCCO CANNON
NEVER-DRY PEN
Writes for Months
REPLACES OTHER MAKES • USES REGULAR INKS
Regardless of pulsations or other causes of ink failures this Never-Dry Pen will make clean and complete records.
CHECK THESE EIGHT FEATURES
1. Always a continuous flow. No unrecorded records.
2. Holds sufficient ink for several months recording.
3. Constant weight for more accurate measurement.
4. Always clean, uniform records due to uniform flow.
5. No ink slopping or dripping in meter cases or on floor.
6. Uses regular recording inks or fast drying inks.
7. Stainless steel assures long and trouble-free service.
8. Used on practically any type of recording instrument.
Now made in 5 sizes. When ordering, specify make and type of recording instrument. Send for Bulletin 110-R3
$6.90 Each Net
Send for Quantity Prices
ARCCO INSTRUMENT COMPANY, INC.
7144 EAST CONDOR STREET · LOS ANGELES 22, CALIF.
MANUFACTURERS OF PRECISION INSTRUMENTS
SEND FOR BULLETIN No. 110-R3

Richard S. Titera has been appointed chief field engineer for asphalt operations, Douglas Oil Co. of California and United Asphalt Co. Prior to joining Douglas Oil, Titera was with the Los Angeles office, The Asphalt Institute, for three years. He graduated from the University of California. Douglas Oil is a participant in United Asphalt along with Envoy Petroleum Co. and MacMillan Petroleum Corp.

Titera

D. F. M. McCormick has transferred to Industrial Raw Materials Corp. from The Atlantic Refining Co. He spent 26 years in Atlantic's Research & Development and Technical Services Department. He is a specialist in the field of waxes, lubes and polymers. **W. H. Tilley** has left Atlantic to join Du Pont Co. in Philadelphia, Pa.

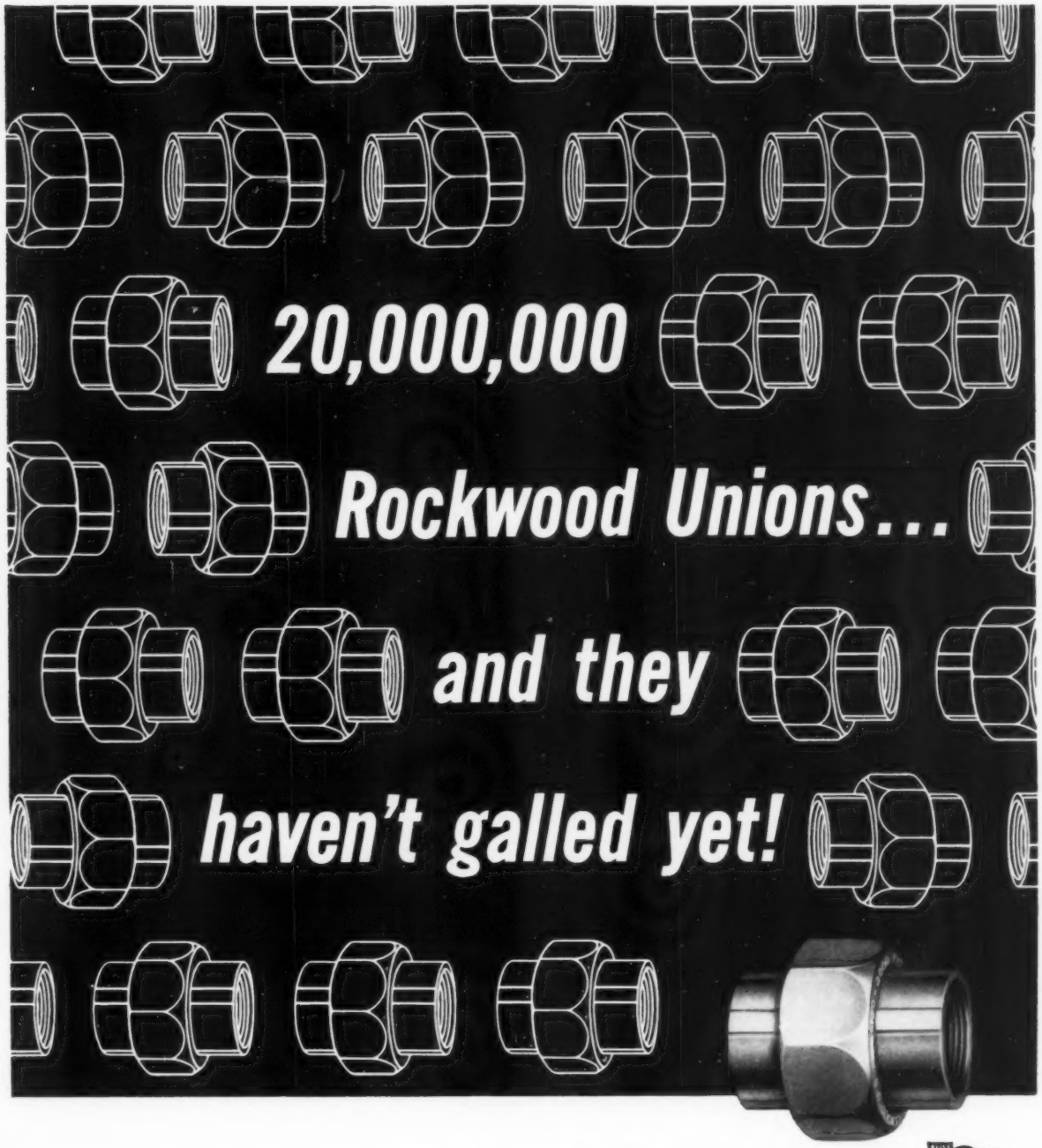
Dr. Charles K. Lawrence has been appointed assistant to the director of research and development, Allied Chemical Corp. Dr. Lawrence joined the company as a research chemist in 1928. He has held various supervisory positions in research and was named associate director, Nitrogen Division's research and development center, Hopewell, Va., in 1958. He graduated from Harvard University in 1923 with an A.B. degree. He earned his Ph.D. degree from Massachusetts Institute of Technology in 1927.

Robert F. Ichord has been named manager, Shell Chemical Co's Administration Department. Ichord joined Shell in 1930 in St. Louis. Prior to his new appointment, he was manager of the Organization Division, Shell Oil Co.

Dr. Lawrence A. Kimpton has joined Standard Oil Co. (Indiana) as general manager of planning. Dr. Kimpton will supervise activities concerned with long-range planning and industry and general economics. He will continue as a member of Standard's board of directors.

Kerryn King, formerly vice president in charge of the Employe and Public Relations Department, Texaco, Inc., has been named vice president and assistant to the chairman of the board of directors of Texaco. He was appointed director of public relations in 1953, and was ad-

For more data on advertised products, use Readers' Service Cards, last page.



Only ROCKWOOD Cold Forged Steel Unions have the hardness differential which *assures* fast, easy make-up, a tight seal, and free from galling. Male seat is heat-treated to a hardness substantially higher than that of the female seat. Then both seats are forged in place and double-locked under 100,000 and 400,000-pound pressures. Other outstanding features include: special color-coding for immediate identification, Rockwoodizing which gives all surfaces *positive* protection against corrosion, interchangeable parts. Get complete information now. Write for facts.

ROCKWOOD SPRINKLER DIVISION

Distributors in all principal industrial areas

ROCKWOOD SPRINKLER DIV.
of The Gamewell Company
A Subsidiary of E. W. Bliss Company
723 Harlow Street
Worcester 5, Massachusetts

Please send me prices and further information on Rockwood Unions.

Name .....
Title .....
Company .....
City ..... *Zone* .....
State .....

For more data on advertised products, use Readers' Service Cards, last page.

BONDSTRAND®

An imaginative solution to your piping problems

From Missile Research...
A new product for process piping

- Twice as strong as steel
- 1/4 the weight of steel
- Inherently resistant to chemicals which attack stainless steel

Bondstrand is a corrosion-resistant, high strength, rigid pipe made of glass filaments bonded in chemically inert synthetic resins. It is capable of withstanding high pressure and the corrosive attack of many salt, acid, and alkaline solutions. The outside surface is equally resistant because the pipe is made entirely of corrosion-proof materials. No painting or maintenance is necessary.

Bondstrand's light weight and ease of assembly can save up to 50% of installation costs. Actual cost records of typical applications prove that the total installed cost averaged only 1.3 times that of carbon steel pipe. By eliminating the corrosion problem and down time for replacement or repair, Bondstrand saves many times its slightly higher initial cost.

Bondstrand is now available in sizes from 2" through 8" with all necessary couplings and fittings. Larger sizes available on special order.

Write for bulletin containing complete data, including physical properties, chemical resistance, flow rates, and other design information.

Amercoat® CORPORATION 126

A Subsidiary of American Pipe and Construction Co.

Dept. VJ, 4809 Firestone Blvd., South Gate, California

921 Pitner Ave. Evanston, Ill. | 360 Carnegie Ave. Kenilworth, N.J. | 111 Colgate Buffalo, N.Y. | 2404 Dennis St. Jacksonville, Fla. | 6530 Supply Row Houston, Tex.

Men . . .

vanced to assistant general manager, Employe and Public Relations Department in June 1957, and to general manager three months later. He was elected vice president of the department in 1958.

Gordon M. Jones, assistant vice-president and director of construction, The M. W. Kellogg Co., has been elected a member of the executive committee of the National Constructors Association, a trade group of industrial engineering and construction firms. Jones will fill a vacancy caused by the resignation of another Kellogg official, Joseph Smith, who has been transferred to Kellogg International, London.

Jones

S. P. Blumberg has been promoted to research specialist, Research and Development Division, Humble Oil & Refining Co.'s Humble Division, Baytown, Texas. He is now serving on a rotational assignment as head of the control and specification laboratory at the new polyolefin plant, Humble's Baytown refinery. Blumberg holds a B. S. degree in chemical engineering from The University of Texas.

Dr. Garbis H. Keulegan, of the fluid mechanics section, National Bureau of Standards, has received a U. S. Department of Commerce Gold Medal for Exceptional Service. He was cited for his fundamental work on open channel flow, water waves, and modeling laws underlying the science of density-current flows.

Herbert C. Thober has been appointed manager, Sun Oil Co.'s Toledo, Ohio, refinery. Thober joined Sun at Toledo as a laboratory technician in March 1941, after his graduation from Purdue University in 1940 with a B.S. degree in chemical engineering. **Koerner E. Leutz** replaces Thober as refinery superintendent at Toledo, and **John F. McKinney, Jr.,** succeeds Leutz as assistant superintendent.

Irvin C. Staeuble has been named assistant manager, Standard Oil Co.'s (Indiana), Sugar Creek, Mo., refinery. He succeeds **P. Craig Livesay,** who is being transferred to the Manufacturing Department general office, Chicago. Staeuble joined Standard Oil as a chemist at the Sugar Creek refinery in Feb-

For more data on advertised products, use Readers' Service Cards, last page.

Cooling towers destroyed by fire replaced in twenty-one days

July 12, 1960—Fire destroyed two cooling towers on an 80 ft. high roof at the E. F. Drew & Co., Inc., plant, Boonton, N.J. With production loss estimated at $20,000 per day, speedy replacement was imperative.

July 15—Two new towers were ordered from Foster Wheeler.

July 18—Replacement towers were shipped from FW's *California* plant—three days after receipt of the order . . . six days after the fire.

July 26—Field erection of the towers began.

August 5—Both cooling towers were completed four days ahead of schedule . . . a schedule which represented the best estimated completion time submitted by any manufacturer when the job was bid.

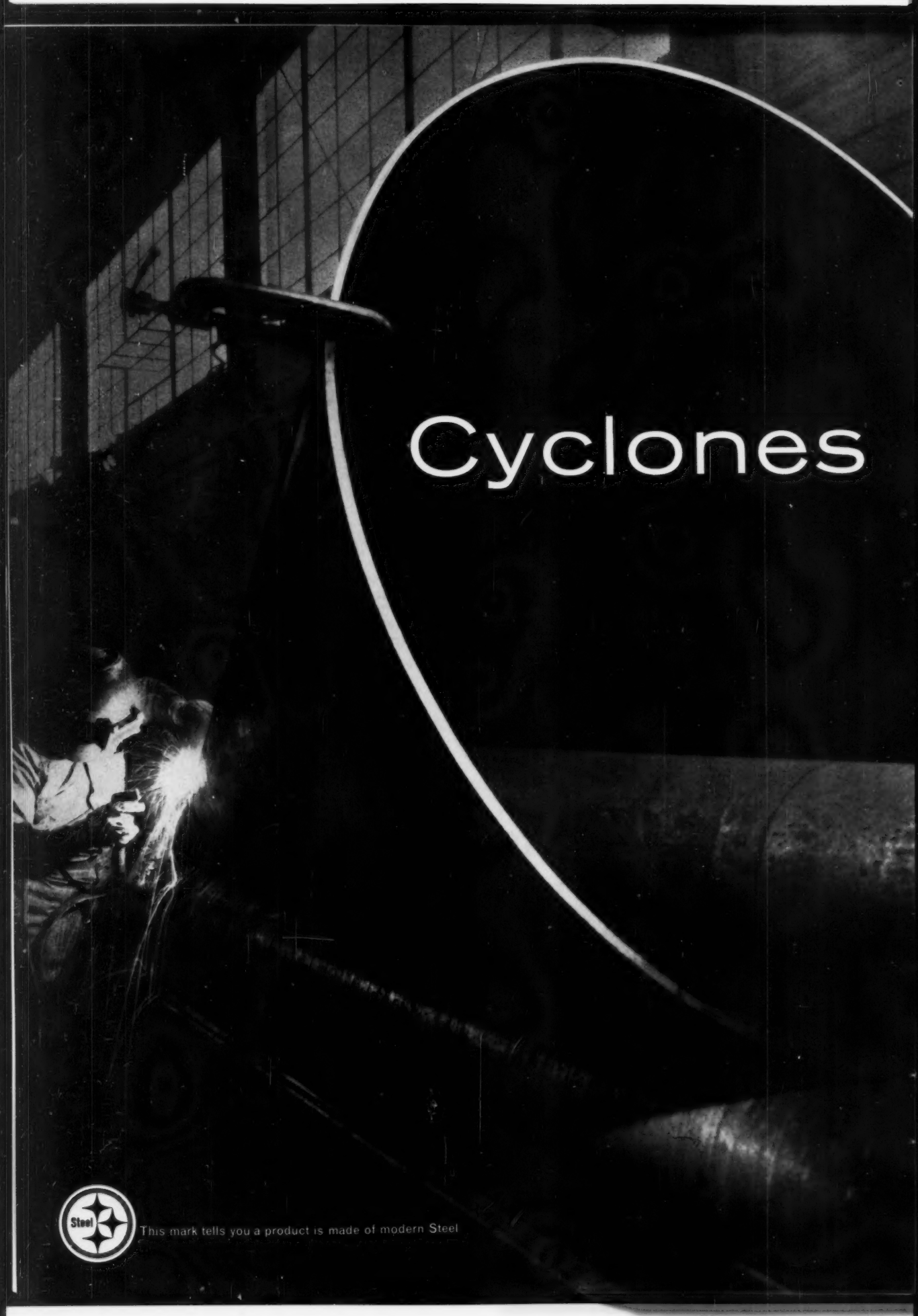
How? Fine teamwork on the part of Drew Co. and Foster Wheeler, plus the availability of FW's pre-engineered towers, pre-fabricated assemblies, and experienced field erection made this performance possible. And quality did not suffer because of speed! These towers were *un-hurriedly* engineered, carefully pre-cut, and fully air-dried long before receipt of the order.

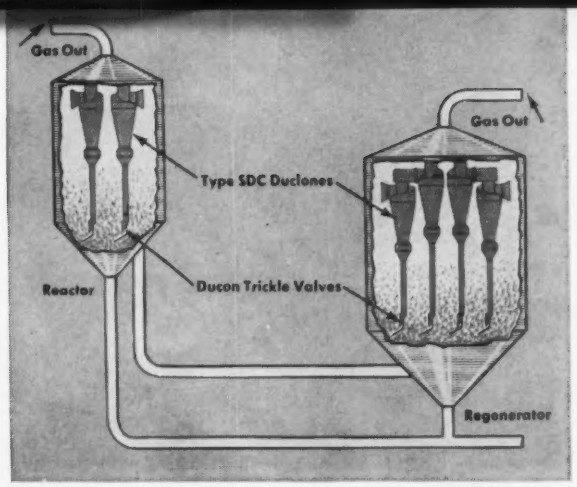
In every Foster Wheeler cooling tower, the dimensions and quality of the redwood, coupled with proper wood-preserving treatment, are your safeguard against delignification and chemical or biological attack. A full range of sizes and casing materials are offered. Write to Foster Wheeler Corporation, 666 Fifth Avenue, N.Y. 19, N.Y.

FOSTER WHEELER

NEW YORK LONDON PARIS ST. CATHARINES, ONT.

For more data on advertised products, use Readers' Service Cards, last page.


Cyclones
Steel
This mark tells you a product is made of modern Steel



General arrangement of Ducon cyclones in the reactor and regenerator of a fluid catalytic cracking unit. Stainless cyclone collectors keep catalyst loss to a minimum. "Duclone" is a registered trademark of the Ducon Co.

start here...

. . . and end up in fluid bed cat crackers where they circulate up to 60 tons of catalyst every minute. At $400 to $500 a ton, lost catalyst can put a lot of red ink into a refinery's operating budget. Breakdowns cost from $20,000 to $50,000 a day. That's why it is so important to design with the right material from the start: USS Stainless Steel.

Stainless Steel cyclones used for catalyst recovery are subjected to extreme heat and erosion. Temperatures in a regenerator unit can go as high as 1400° F. At high temperatures elemental sulfur corrosion would eat out most materials in nothing flat. Not Stainless. And Stainless Steel retains its strength at high temperatures. Stainless cyclones aren't in danger of changing shape which could cause catalyst loss.

Nothing equals Stainless Steel as a solution to the many complex problems in a refinery. It has outstanding corrosion resistance for a wide range of reagents, excellent high temperature strength. Its smooth, dense surface won't harbor contamination, is easy to clean. Above all, USS Stainless Steel promises long life and low maintenance. Order USS Stainless Steel through your USS representative or your local Steel Service Center.

If you are interested in more information about these Stainless Steel cyclones, wire or write U.S. Steel, Room 6104, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

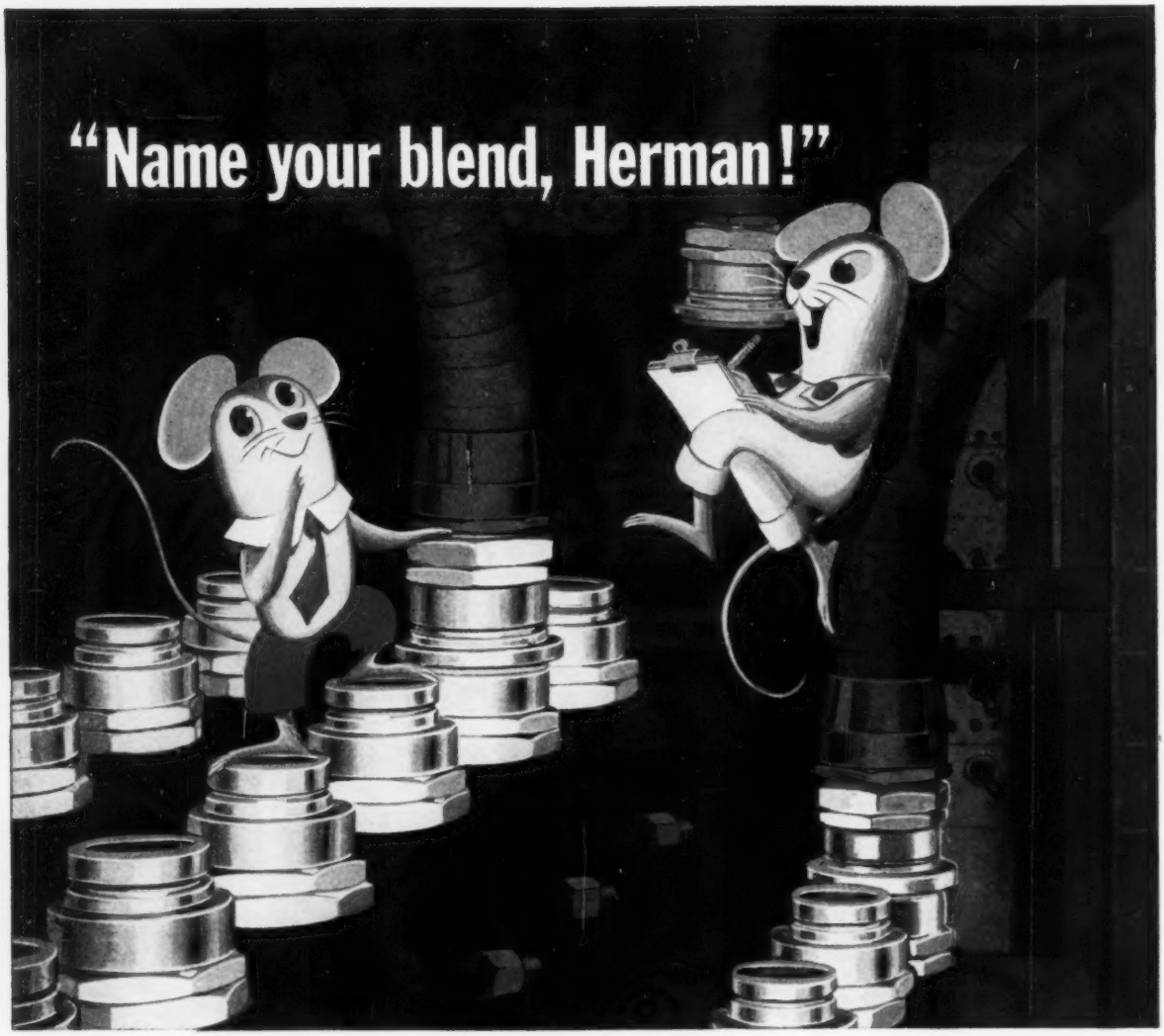
USS is a registered trademark

Left, welder completes longitudinal seam of one segment of the cyclone at The Ducon Company's Mineola, N.Y. plant. **Below,** stainless steel cone is removed from the forming rolls.

USS

United States Steel Corporation—Pittsburgh
American Steel & Wire—Cleveland
National Tube—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel



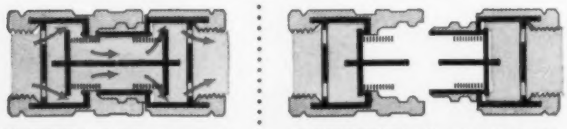
Here's the new, easy way to blend fluids: with Snap-Tite valved couplings on flexible lines

Now there's no need to laboriously open and close a lot of shut-off valves when you're blending petroleum products or other chemical fluids. With Snap-Tite valved couplings on flexible lines you can quickly switch hoses to any base stock line as required. Mixing is faster: you can perform more operations at one time . . . with no danger of contamination of base stocks by interflow through leaky valves! Valves with Snap-Tite couplings instantly shut off the flow when disconnected, and prevent run-out from overhead lines.

Under this arrangement, you store only base stocks to achieve infinite variations in blending. Not only do you save space, time and labor, but by eliminating shut-off valves and associated headers and permanent piping, you save substantially on equipment. In a recent installation (Standard Oil at Richmond, Cal.) the coupling cost was approximately one-third that of permanent piping!

For information, write for Snap-Tite Catalog No. 59. Ask for the name of your local Snap-Tite representative. There is no obligation.

TO USE SNAP-TITE VALVED COUPLING:



CONNECT—Full flow instantly

DISCONNECT—Stop flow instantly

☆ Snap-tite

ST-59-05

UNION CITY, PA.

Men . . .

ruary 1931. He became assistant foreman in the Asphalt and Pressure Stills Department in 1940. By 1946 he had been promoted to general foreman in the Cracking and Asphalt Department and in 1949 was named superintendent of the Process Division. He has been assistant manager of the refinery since June 1953.

H. E. Cier has been promoted to senior research specialist, Baytown, Texas, Research and Development Division, Humble Oil & Refining Co.'s Humble Division. He is now serving on a rotational assignment in Humble's Technical Division there. In the solvents section, he is coordinating the production of large-volume samples of new products at the specialty fractionating unit for evaluation by potential users. Cier holds a B.S. degree in chemical engineering from Louisiana State University.

Cier

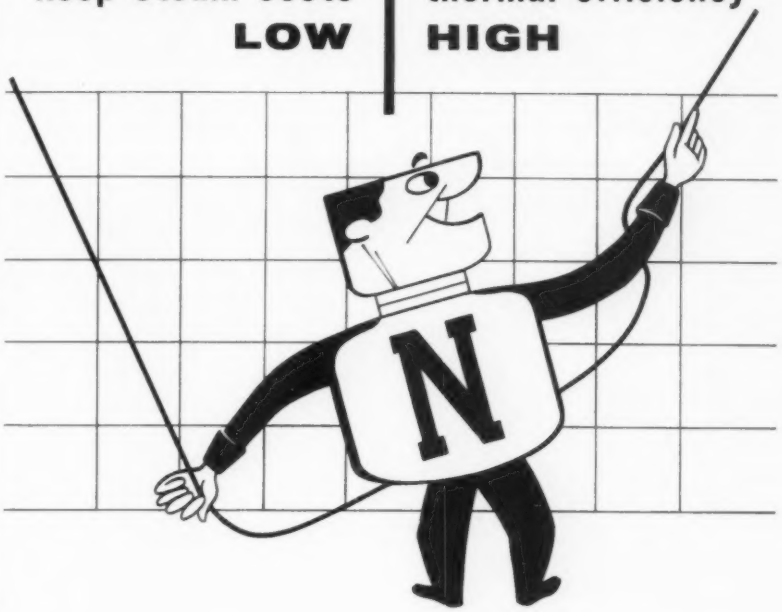
F. Carl Hirdler, Jr., has been appointed, technical supervisor, Petroleum and Petro-Chemical Division, Turco Products, Inc. During his 17 years with Turco, Hirdler has concentrated upon petroleum refinery consultation, and chemical additive usage in petroleum processing. He is a registered professional chemical engineer of California. He received his B.S. in chemical engineering at the University of Oklahoma and his M.A. at Los Angeles State College.

James A. Petrie, Jr., has been appointed assistant to the president, Kellogg International Corp., London. Petrie is a vice president and director of KIC in addition to being an assistant vice president of The M. W. Kellogg Co., New York. Kellogg International is a subsidiary of The M. W. Kellogg Co.

Robert Bredeson, James H. O'Neal, Robert O. Robertson and John D. Tackett have been appointed project engineers, Manufacturing Department, Amoco Chemicals Corp. Bredeson and O'Neal were previously employed in the General Engineering Department, Standard Oil Co. (Indiana) at Whiting. Robertson was formerly assistant chief

Nicholson Thermostatic Steam Traps

keep steam costs **LOW** | thermal efficiency **HIGH**



Low costs and high efficiency! Nicholson Traps give you both . . . by *design*. And here's how. Hardened stainless steel seats and valves are accurately lapped for sure, tight shut-off . . . so, there is no waste of live steam. True balanced pressure . . . the operating principle of these valves . . . assures fast intermittent discharge of condensate and air, resulting in maximum thermal value from every pound of steam produced.

As for capacity, these traps *really* have it . . . up to six times greater than ordinary traps. Maintenance? Practically none, for there is only one moving part. No links no pins. No pivots or levers. No adjustable orifices to stick or clog.

Sure, some traps cost less than Nicholson . . . but the 'savings' exist only on the invoice. In actual use, some other traps can cost you three or four times their price in annual steam waste. Be sure to weigh cost against value when *you* buy steam traps. Specify Nicholson Thermostatic Steam Traps on your lines and equipment.

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STREET _____
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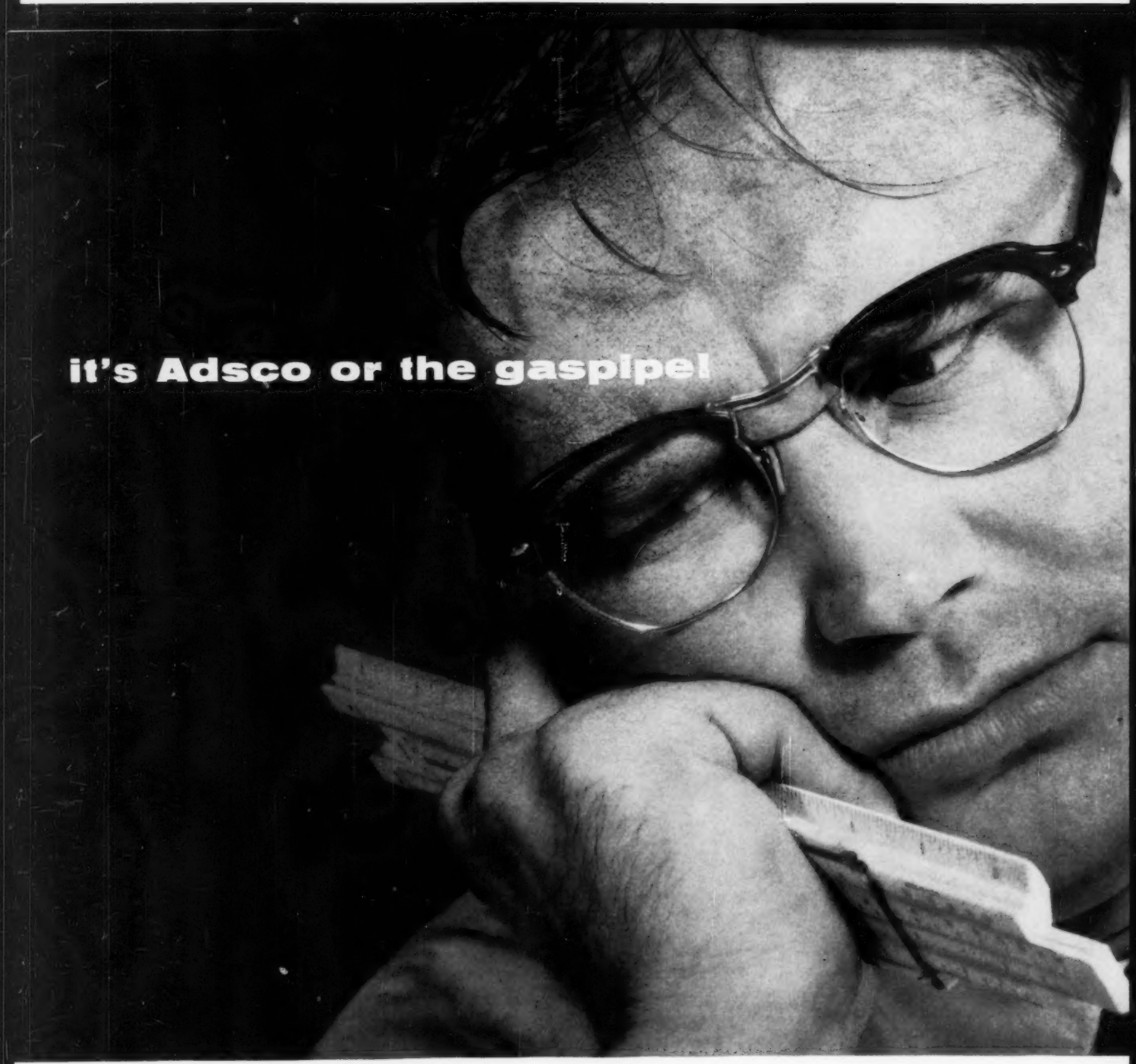

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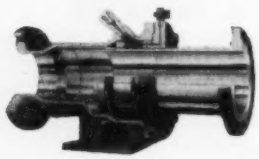
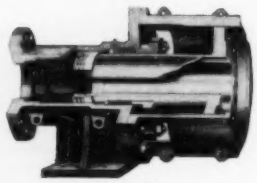


RAM-PAK



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Men . . .

engineer at American Oil Co.'s Destrehan refinery. Tackett was with Service Pipeline Co. before joining Amoco Chemicals.

Thomas E. Workman has joined the process engineering staff of Catalytic Construction Co., Philadelphia. A chemical engineering graduate of Rice University, Workman recently returned from Korea, where he supervised projects for paint, pharmaceuticals and other chemicals production. He has been in chemical engineering work with Monsanto, Union Carbide, Production Constructors and Smith, Hinchman and Grylls. At Catalytic he will be planning multiproduct petrochemical plants including economic and engineering investigations.

Workman

Thomas R. Young, formerly a partner with Singmaster and Breyer Co., has joined Houston Chemical Corp. as vice president in charge of operations. Young's duties include supervision of construction of the company's new plants. His experience covers the field of chemical engineering operations in heavy and fine chemicals, electrolysis and extractive metallurgy. He was employed for several years in the tetraethyl lead manufacturing section of Du Pont's Deepwater chemical plant.

Young

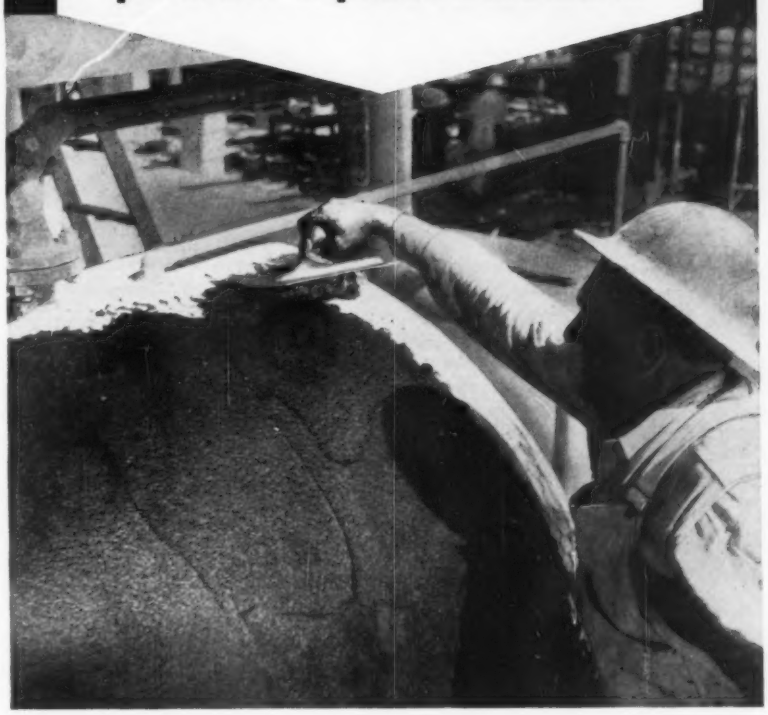
J. L. Christian has been elected to the board of directors, Monsanto Chemical Co. Christian, of St. Louis, is presently a vice president of the company. **Edward J. Bock** and **Tom K. Smith, Jr.,** have been named vice presidents. Bock succeeds Christian as general manager, Inorganic Chemicals Division.

G. Franklin Montgomery has been selected to head the Instrumentation Division, National Bureau of Standards. He was formely chief, electronic instrumentation section. He joined the bureau in 1946. He graduated from Purdue University in 1941.

Frank V. Williams has been assigned to Standard-Vacuum Oil Co.'s Durban, South Africa, refinery, where he will

Laykold® WEATHERCOAT

protects exposed insulation



INSULATION on towers, tanks and exchangers must be kept DRY. If moisture gets through, the efficiency drops.

Modern refinery and plant design places many major insulated vessels "in the open." You can maintain the efficiency of your insulation with easy-to-apply Laykold Weathercoat.

Weathercoat is a fibrated asphalt-base material of easy troweling consistency that dries to a black, remarkably tough and tenacious coating. A majority of the leading refineries are regular users of Weathercoat.

A new product: Mastic Weathercoat, a bodied material, for use wherever economy demands the application of a *single,* thick layer.

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PRODUCT IMPROVEMENT WITH PETRECO

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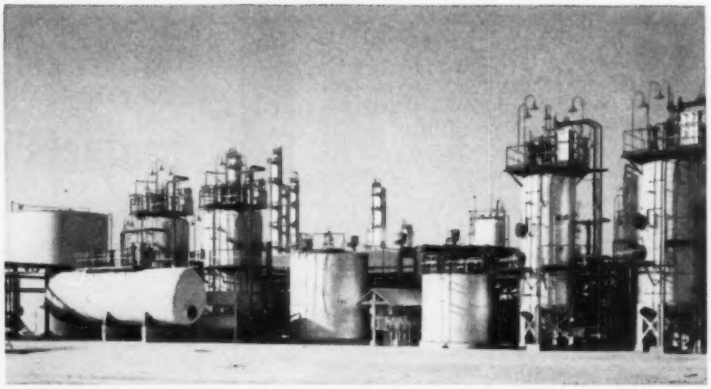


Six versatile Petreco treating units handle a wide variety of purification problems for the Richfield Oil Corporation refinery at Watson, California. This compact Petreco installation has a distillate capacity of 60,000 bpd and treats 19 streams, yet it occupies an area equal to only 50 x 100 feet of ground space. By using modern Petreco equipment, Richfield is able to supply increased demands for better gasoline, jet fuels, stove and diesel oils, and at the same time make substantial savings in time and money.

The purification equipment installed by Richfield during a three-year period—1955 to 1958—consists of five Petreco ELECTROFINING* Precipitators and a Bender Catalytic Sweetener. These units were selected to provide a complete flexibility:

A *Stove Oil-Jet Fuel Treater* replaced an older unit in order to meet more stringent specifications for jet fuel.

A *Cycle Oil Treater* was in stalled to produce a stable product which can be used as a component of locomotive diesel fuel or No. 2 burner oil.

Two *Gasoline Treaters* were installed to remove hydrogen sulfide from straight run gasoline.

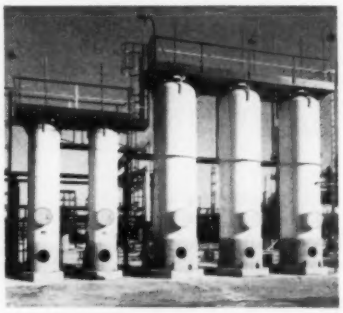
A *Diesel Oil Treater* was installed to give greater efficiency in removing naphthenic acids, and to stabilize the product.

A *Bender Treater* was installed to sweeten distillates from various sour crude stocks.

Bender sweetener vessels consist of two sulphur absorbers and three catalyst towers. Four of the ELECTROFINING units are two-stage treaters; one is single stage.

Richfield has realized these important advantages after installing Petreco treating equipment:

Saving in equipment costs. Continuous treating and "on-stream" blending have largely eliminated the need for intermediate storage vessels. A wide range of products is treated in a much smaller area than other treating equipment requires. *Savings in maintenance costs.* Thorough removal of spent caustic from straight run gasoline keeps exchangers and re-boilers in fractionating equipment operating with a minimum of fouling. *Savings in production costs.* Efficient treating reduces chemical consumption. Spent reagents are effectively removed from distillates. Product loss is low, because electrical separation leaves only a negligible amount of oil in spent reagents. *Savings in labor.* Automatic operation reduces labor requirements and gives more efficiency. *Safe, clean facilities.* All equipment is vapor-tight, for greater safety and cleanliness. There is no air pollution. *Improved product quality.* Treated products contain less sodium, naphthenic acid, mercaptans, sulphur, and color bodies. Storage qualities are greatly improved. Jet fuel passes all specifications without re-treating.



Call on Petreco for sound suggestions for improving your refinery's treating facilities.

DT-60-1

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Men . . .

serve as refinery manager. He holds a B.S. degree in mechanical engineering from Drexel Institute, Philadelphia. He joined Stanvac as assistant manager, Lube & Special Products Supply Department in 1955. He became manager of that department in 1958.

Dr. Herman S. Bloch has been appointed associate director of process research, Universal Oil Products Co.

Bloch

Hoekstra

Pollitzer

Cox

James Hoekstra and **Dr. Ernest L. Pollitzer** have been named research coordinators, process research. **Dr. William L. Cox** has been made research coordinator, products research.

J. C. G. Boot, who has resigned from the board of Shell International Petroleum Co., has been named to the board of Bataafse Internationale Petroleum Mij. Boot will be transferred from London to the Hague, Netherlands. He has served as personnel coordinator for Royal Dutch Shell.

Dr. D. G. Walker has been promoted to senior research chemist, Baytown, Texas, Research and Development Division, Humble Oil & Refining Co.'s Humble Division. He is engaged in fundamental studies of the structure of acidic

SWECO process equipment...

Three Ways More Dependable

Seasoned Engineering Staff
SWECO engineers are constantly meeting petroleum industry challenges of new extremes in temperature and pressure. They develop improved equipment designs and methods to obtain the highest thermal and mechanical efficiency for economical, long-range operation.

Specialized Production Facilities
Construction of heat exchangers, pressure vessels, steam jet ejectors and other process equipment requires special production skills, equipment and experience. SWECO's 40 years of fabrication experience, much of it with special metals and alloys, results in high quality standards and reasonable production costs. Continuous quality control is maintained throughout production with all SWECO equipment thoroughly tested before shipment.

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A *single* SWECO Sales Engineer serves as your project co-ordinator and expediter. He communicates your equipment requirements to engineering and works closely with production to assure that your specifications and delivery dates will be met. Because he *knows* your unit, he gives you straight answers and immediate service.

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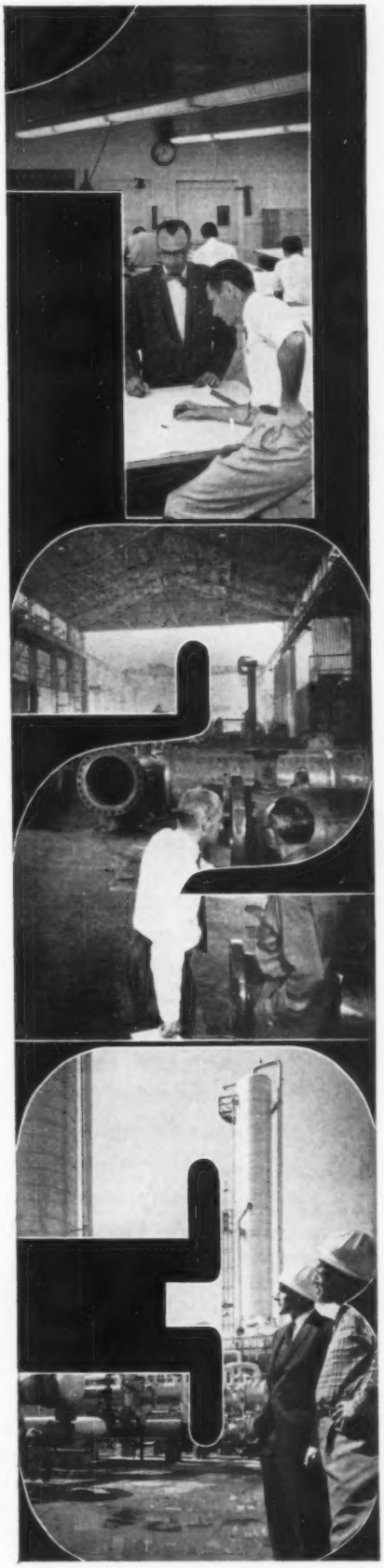
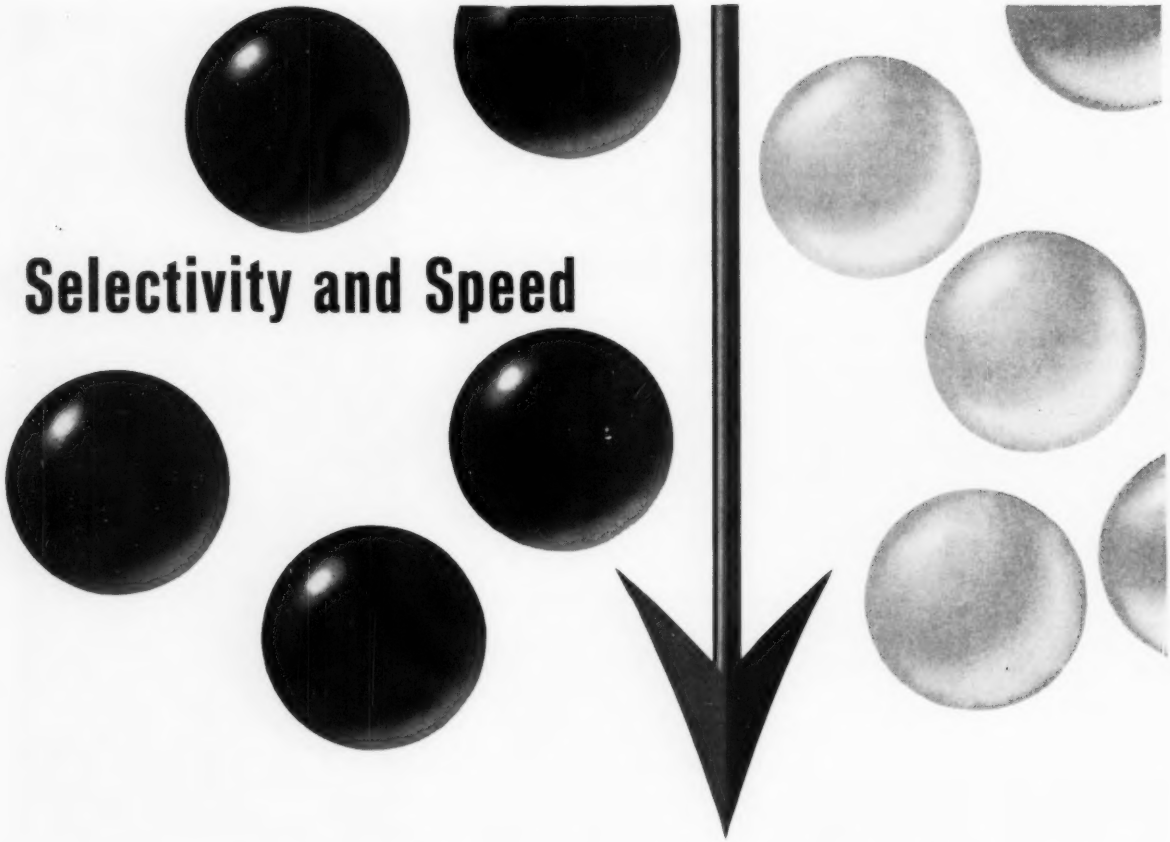
For illustrated literature on SWECO heat exchangers, pressure vessels, steam jet ejectors and other process equipment, write for your copy of Bulletin 14-333.



For more data on advertised products, use Readers' Service Cards, last page.



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QO Furfural is a polar molecule and gives sharp separation of saturates from unsaturates in lube oils, gas oils, cycle stocks and other petroleum products. Furfural is equally selective in the extractive distillation of C_4 hydrocarbons to give high purity butadiene. It is even effective in the separation of organic sulfur compounds or heavy metal complexes from petroleum fractions.

The high specific gravity of QO furfural permits rapid phase separation. Of course, fast refining means efficient, economical refining.

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A/S "Ota", Copenhagen, S. Denmark

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For more data on advertised products, use Readers' Service Cards, last page.

Men . . .

type catalysts and of the conversion processes that can be effected by them in the manufacture of chemicals and fuels from petroleum. Dr. Walker holds the B.S. degree in chemical engineering a B.S. degree in chemical engineering and a M.A. and Ph.D. degree in phy- Texas.

Morris Morrow has joined Esso Research and Engineering Co. from Humble Oil & Refining Co. to begin a one-year rotational assignment. He will head the products application section. At Humble, he was head of the product quality section, Research Department, Baytown, Texas.

Charles A. Rothfus has been elected executive vice president, Colorado Petroleum Council. He succeeds **A. C. (Bill) Rose** who has resigned. Rothfus has served for the past two years as assistant secretary of the Kansas Petroleum Industries Committee. He graduated from the University of Oklahoma and has been in petroleum industry work for about 12 years. He has also served as a district representative in Kansas and Oklahoma for the API's oil Information Committee.

Rothfus

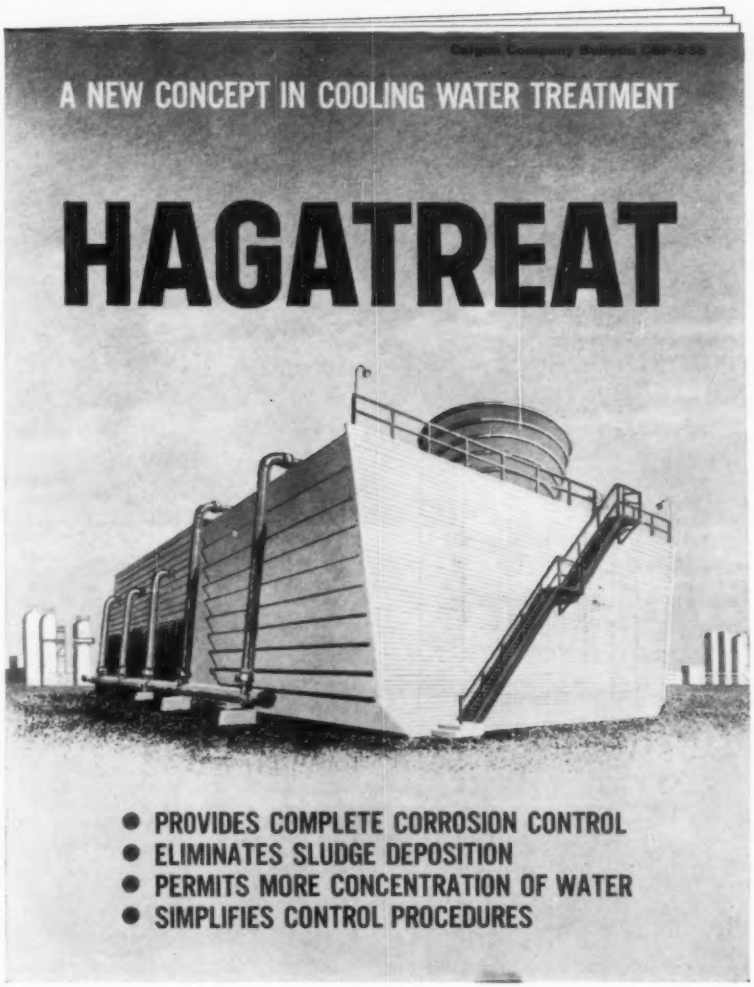
Edwin F. Nelson has rejoined Universal Oil Products Co. as a consultant for process sales and engineering. He was a vice president of Universal from 1945 to 1952. He served eight years as president of Lake Superior Refining Co. He first joined UOP in 1926.

Weldon R. Burns has been appointed engineering manager Badger, Ltd., London, affiliate of Badger Manufacturing Co., Cambridge, Mass. Burns joined the British affiliate after his assignment as project manager on the $50-million Esso Rotterdam refinery recently completed by Badger N.V. He came to Badger in 1957, after 24 years with Bell Oil and Gas, Northwestern Refining, Frontier Refining, Catalytic Construction and Badger Manufacturing Co's. predecessor, E. B. Badger and Sons. He holds a B.S. degree in petroleum engineering from the University of Oklahoma.

J. C. Weisinger has been promoted to staff engineer in the petrochemicals section of the Technical Division, Baytown, Texas, refinery, Humble Oil & Refining Co.'s Humble Division. He is

SEND FOR IT —READ IT —PROFIT BY IT

a new bulletin on a new product by Hagan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HAGATREAT
● PROVIDES COMPLETE CORROSION CONTROL
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Hagatreat, an entirely new concept in the treatment of cooling water, prevents scale and sludge formation in the system and permits higher concentration of make-up water. Results, savings in both chemicals and water costs. In tests covering several years, corrosion of both steel and copper was held to a minimum unmatched by any previous inhibitor.

Get the complete story. Bulletin CSP-935 contains all the information on applications, plant handling, and test results. See how your cooling water system can operate more efficiently . . . more profitably. Write:

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AIRETROL

Compact, fast, efficient, easy to operate. Air-powered tube rolling up to twelve ¼" to 1½" OD tubes per minute. Precision pneumatic control stops expansion automatically within .001" of predetermined setting.

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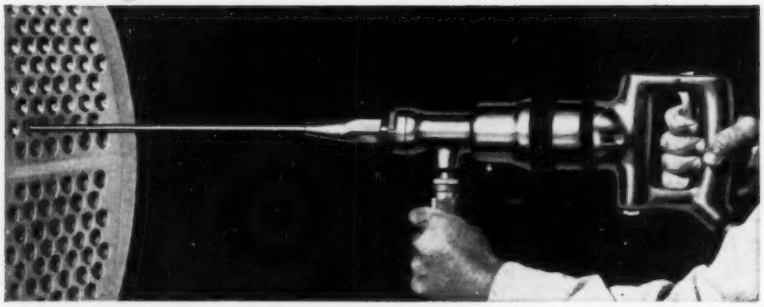

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Lightweight condenser cleaner with air driven motor. Easy, one-man operation with no rig. Hard deposits and completely plugged tubes quickly and efficiently reamed out. Built-in flushing system washes cuttings away and cools the drill.

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Men . . .

engaged in economic evaluations of potential petrochemical projects. Weisinger received a B.S. degree in mechanical engineering at Texas A&M College.

Howard E. Padgett has joined Crawford & Russell, Inc., Stamford, Conn., as construction manager, Southern Division. Padgett, who formerly was employed by The M.W. Kellogg Co. as a construction superintendent, has over 20 years experience in chemical plant and petroleum refinery construction. He has been responsible for the construction of catalytic cracking plants, Hydroformer units, and plants for producing polyethylene, ethylene, phenol, methanol, and asphalt.

Padgett

Ronald W. Dunlop has been named head of Imperial Oil Co., Ltd.'s, Manufacturing Department. Dunlop's first job with Imperial was as a draftsman at the Calgary, Alta., refinery, where he later became mechanical superintendent. He was appointed an assistant general manager, Manufacturing Department in 1956.

Ronald H. Brierley has joined the Research Department, Monsanto Chemical Co.'s Lion Oil Co. Division at the company's Texas City, Texas, plant, after serving with the American Oil Co. there.

Alfred R. Crosby has been named an engineering associate by Esso Research and Engineering Co. Crosby has been with the company since 1947.

Richard C. Sauer has been elected an executive vice president, Standard Oil Co. (Ohio). Sauer was a senior vice president. **Elliott B. McConnell** has been switched from Standard-Ohio's manufacturing to the company's research and scientific management section. Both men are company directors.

George R. McMillin has left his post as refinery manager of Imperial Oil Co., Ltd.'s, Sarnia, Ont., refinery, to become an assistant general manager of the firm's Manufacturing Department. Except for one year with International Petroleum, at Talara, Peru, McMillin's 27 years in

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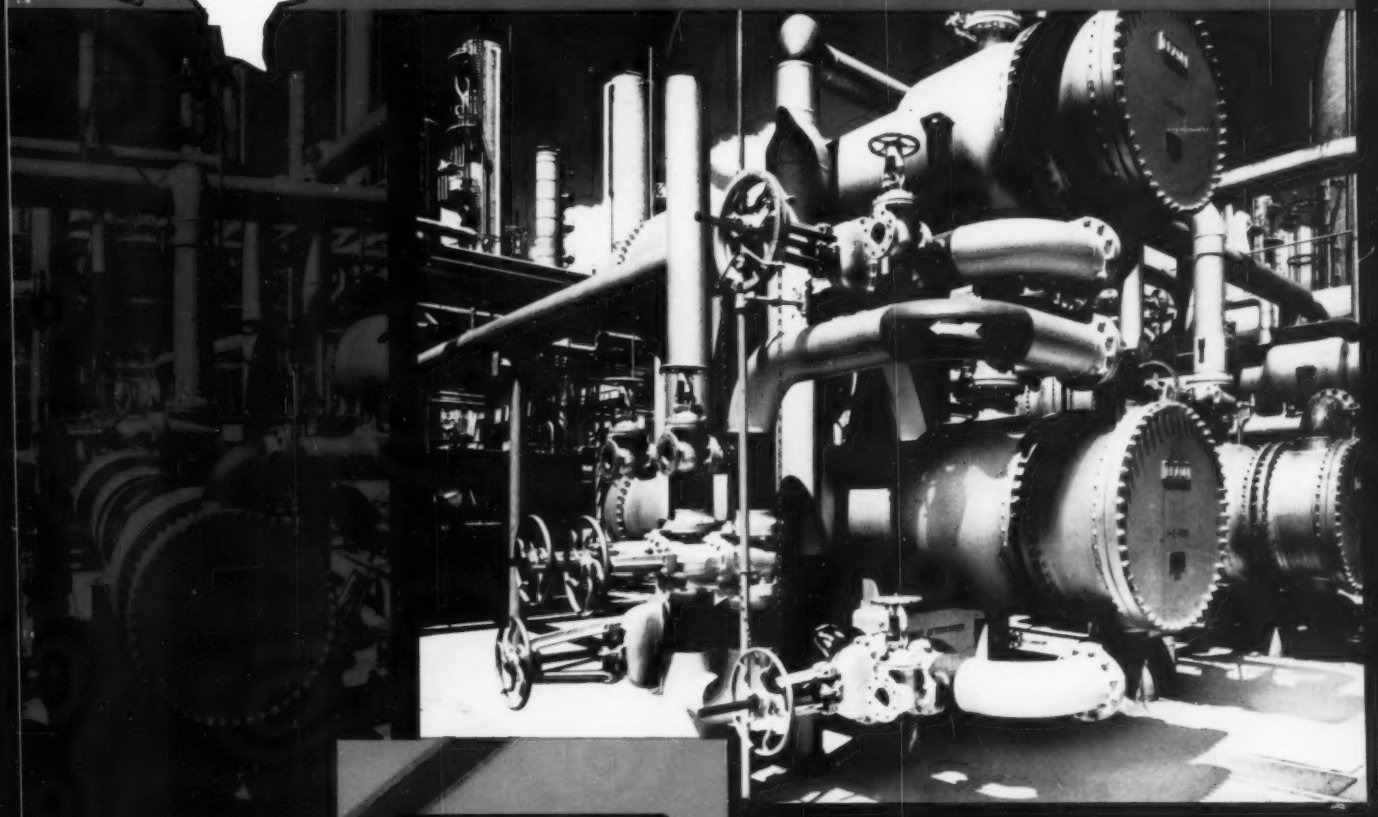

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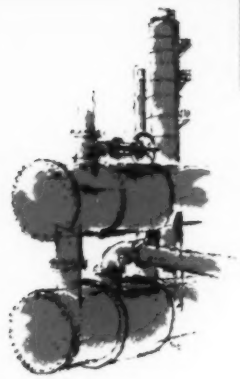

HEAT EXCHANGER TUBE for Applications from Marine to Petrochemical, from Compressor Intercoolers to "Cat-Cracker" Exchangers, in these popular Alloys . . . Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Red Brass, 85% • Deoxidized Copper • Arsenical Copper • Cupro-Nickel, 10%-20%-30% • Aluminum Brass • Aluminum Bronze, 5% • Muntz Metal • Duplex Tube

HEAT EXCHANGER TUBE

As in so many other modern chemical and petro-chemical processing plants, these typical heat exchanger units at the Houston Plant of Petro-Tex Chemical Corporation are tubed with Scovill PHOSPHORIZED (Inhibited) ADMIRALTY Heat Exchanger Tube. This alloy has often been specified by operating engineers for assured trouble-free performance under conditions where dezincification has been a problem and because of its excellent resistance to the effects of sulphur compounds, acid or contaminated fresh or salt waters. The range of permissible conditions for using this alloy is quite wide. Similarly, Scovill's eleven other popular heat exchanger tube alloys have been formulated to meet specific service needs. Scovill Technical Service with an exceptional background of experience in this special field can help you select the alloy best suited to assure trouble-free performance in your installation.

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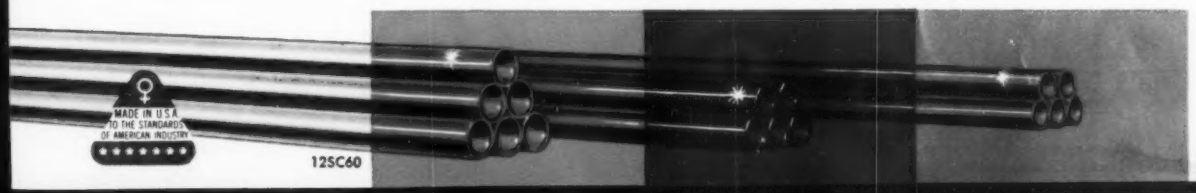

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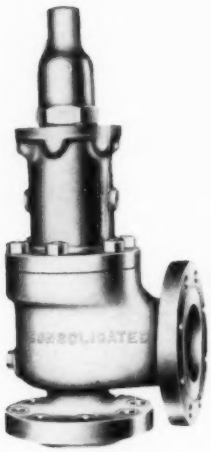
top

CONSOLIDATED SAFETY RELIEF VALVES have a special "O" Ring Seat Seal that stops leakage completely



Consolidated Safety Relief Valves are available in both Standard and Balanced Bellows design for extreme corrosive applications.

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The Seal is a resilient ring set in the valve disc. It maintains no-leak tightness by contact with a specially curved seating surface on the valve nozzle, yet does not carry the seat load imposed by the valve spring.

Tightness is maintained at operating pressures far closer to set pressure than with metal-to-metal seats alone. Tight closure is as efficient after "simmer" as on normal blowdown. Piping strains are absorbed far better by the resilient seal than all-metal seating. If the tough seal is ruined by entrained abrasives, replacement is easy. Seals are available in materials that resist corrosive fluids. Maintenance costs are greatly reduced.

Standard Consolidated Safety Relief Valves have an eductor tube that removes pressure from the closed bonnet. Only the spring controls valve action. You get guaranteed capacity ratings and highest dependability—absolute protection for personnel and equipment. Additionally, there is the economy of converting the Standard valve to the Balanced Bellows type in your own shop. Get complete details. Write for Bulletin 1940.

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A product of

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Valve Division • Tulsa, Oklahoma

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more data on advertised products, use Readers' Service Cards, last page.

Men . . .

the oil business have been spent at two Imperial refineries, Halifax and Sarnia. **W. J. (Bill) Beynon** succeeds McMillin as manager, Sarnia refinery. Beynon has been with Imperial for 27 years.

George H. Unzelman has been named chief refinery technologist for the Western Region, Ethyl Corp. Unzelman, who will make his headquarters in Los Angeles, has been associated with Ethyl Corp. since 1955. After serving in the Refinery Technology Division of Ethyl's Detroit research laboratories, he became a refinery technologist in Tulsa for the Sales Department. For the past two years, he has been a technical assistant in Ethyl's Advertising and Sales Promotion Department. As part of his recent duties, he supervised the production of two motion pictures on safety in refining operations. He has an article appearing in this issue of PETROLEUM REFINER entitled "How to Blend for Volatility."

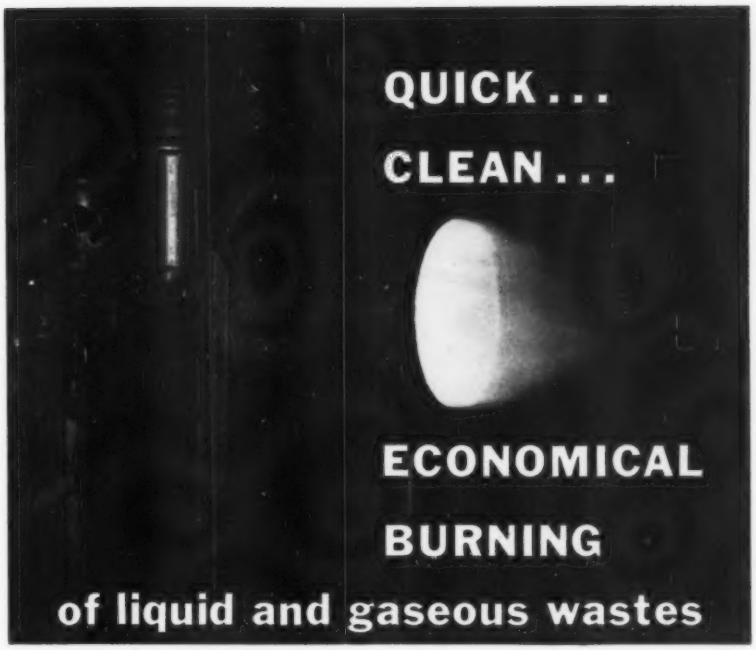
Unzelman

Frank Gaines, Jr., has joined the headquarters of Humble Oil & Refining Co. as coordinator of executive development and organization planning. He attended Michigan State University, where he studied chemical engineering. In 1938, shortly after his graduation from Michigan State, he went to work for Carter as a petroleum engineer at Seminole, Okla.

Harris N. Richard, formerly an instrument technician with Shell Oil Co., Wood River, Ill., has joined the Engineering Department, Monsanto Chemical Co.'s Organic Chemicals Division, St. Louis, Mo.

R. N. Houze has joined the Baytown, Texas, Research and Development Division, Humble Oil & Refining Co.'s Humble Division, along with **J. C. Staton, R. W. White, Dr. R. H. Patton** and **Dr. W. H. Starnes.** Drs. Patton and Starnes are chemists and the others are chemical engineers.

T. A. Wilker, who for the past five years has been manager, Union Carbide Chemicals Co.'s Texas City plant, will move to the firm's New York office as production manager for the company. **H. E. Allspach,** who has been with Union



IN THE THERMAL VORTEX BURNER!

Short, clean flame and compact size make the THERMAL Vortex Burner the perfect solution to many industrial waste disposal problems. Combustible liquid and gaseous wastes can be fed directly into the burner, eliminating the need for expensive, space-consuming incinerators. Combustion takes place quickly with an absolute minimum of smoke and odor. Where necessary, a conventional fuel may be fired to supplement the firing of the waste material. Simply and compactly designed, the THERMAL Vortex Burner can also become the nucleus of an efficient heat recovery system.

THERMAL'S laboratory facilities are available for trial burning of wastes. In addition, our staff of engineers is equipped to do complete turn-key designs to solve your waste burning problems. For further information, write for Bulletin #116.

Some of the waste materials that the THERMAL Vortex Burner has burned include:

1. Paint and lacquer residue.
2. Nitrogen rich petroleum residue.
3. Ethylene dichloride.
4. Aromatic water mixture.
5. Phenol tar.
6. H_2S
7. Nitrated and chlorinated aromatics.

THERMAL

Thermal Research & Engineering Corp.

CONSHOHOCKEN • PENNSYLVANIA

REPRESENTATIVES IN PRINCIPAL CITIES

Other Thermal Products & Services:

Gas, Oil & Combination Burners
Heat Exchangers
Air Heaters
Gas Generators
Submerged Combustion
Combustion & Heat Transfer Equipment

For more data on advertised products, use Readers' Service Cards, last page.

5 LEADING REGIONAL OIL AMERICA'S LEADING

To serve you better coast-to-coast, 5 leading regional oil companies have joined hands to form a new Humble Oil & Refining Company. The name comes from an oil field and a town near Houston, which was the origin of Humble Oil Company almost 50 years ago.

In the fast developing Age of Energy, this is an important move. It joins the skills and resources of all these companies into a single closely-knit organization that now markets products coast-to-coast.

The new Humble is America's Leading Energy Company. It finds, refines, distributes, and markets more natural gas, oil and petroleum products for America's growing needs, than any other domestic oil operation. It is backed by the leading petroleum research laboratories in the nation . . . with more oil and petrochemical advances to their credit than any other U.S. Research group. This new organization under Humble Management offers opportunities for greater efficiencies in oil exploration, drilling, production, transportation and marketing.

The new Humble Oil & Refining Company looks forward to expansion in two important areas.

Geographical expansion – as a marketer with more than 30,000 service stations, now enabled through this move to operate in all 50 states.

New product expansion – not only in improved fuels and lubricants, like the remarkable new Uniflo Motor Oil, but also in the exciting new field of petro-chemistry where hundreds of new and useful products have been improved or developed because of Humble research.

COMPANIES UNITE TO FORM ENERGY COMPANY

IDENTIFIED COAST-TO-COAST BY THESE FINE TRADE MARKS

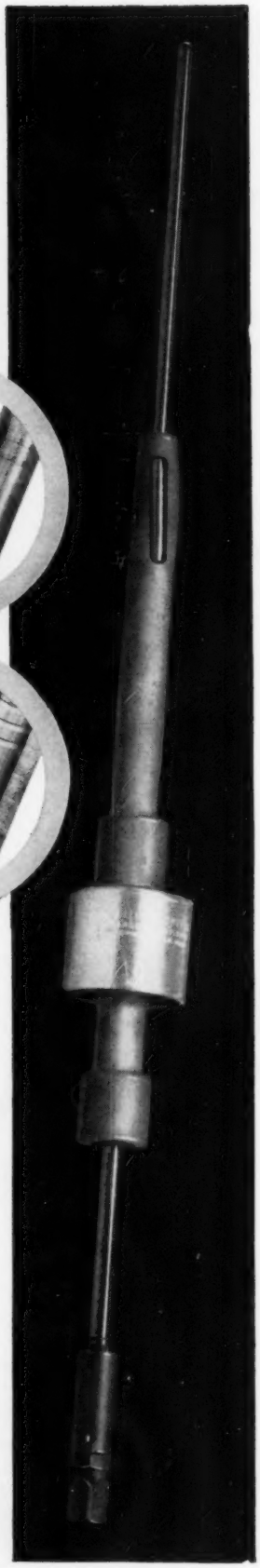
HUMBLE
OIL & REFINING COMPANY

For more data on advertised products, use Readers' Service Cards, last page.

NEW ELLIOTT TUBE EXPANDERS **roll tubes into thick sheets in one pass**

Use of **NEW** continuous-rolling technique here—shows uniform seal, with all Keys preserved, and no signs of shear

OLD step-rolling method results in non-uniform surface . . . distortion of Keys where rolls have overlapped



Better seal . . . Smoother surface . . . Much Faster operation

This new concept in tube expanders was developed by Elliott to roll the thickest tube sheets. Using a continuous-rolling method, it eliminates many problems common to step-rolling, may be operated protractively or retractively, saves time, assures uniform, smooth surfaces, avoids annular voids or erratic tube inside diameters, provides better seal.

Accessories

Elliott also makes a complete line of retubing accessories, including both electric and air magnetic Tube Rolling Controls, Tube Gages, Tube Plugs, Tube Cutters, etc.—in addition to a complete line of tube expanders. *Ask for Bulletin Y-52.*

ELLIOTT Company
LAGONDA PLANT, SPRINGFIELD, OHIO
Y9-5

Men . . .

Carbide 25 years, has been named plant manager at Texas City to succeed Wilker. He was assistant plant manager before his promotion. **Harold Walker,** who has been maintenance superintendent at the Texas City plant, has been promoted to assistant plant manager.

Warren O. Carlson has joined the consulting firm of BEACO, Ltd., Montreal, P.Q., Canada, as vice president in charge of the Refining Division. In this capacity, he will be responsible for all the company's activities in the petroleum refining, petrochemical, and gas processing fields. He will have his offices in Calgary, Alta. Before joining BEACO, Carlson was with the C. W. Nofsinger Co., a consulting engineering firm in Kansas City, Mo. Prior to this, he had many years experience in the engineering and construction of petroleum refineries and related equipment in the United States, Europe and South America.

Carlson

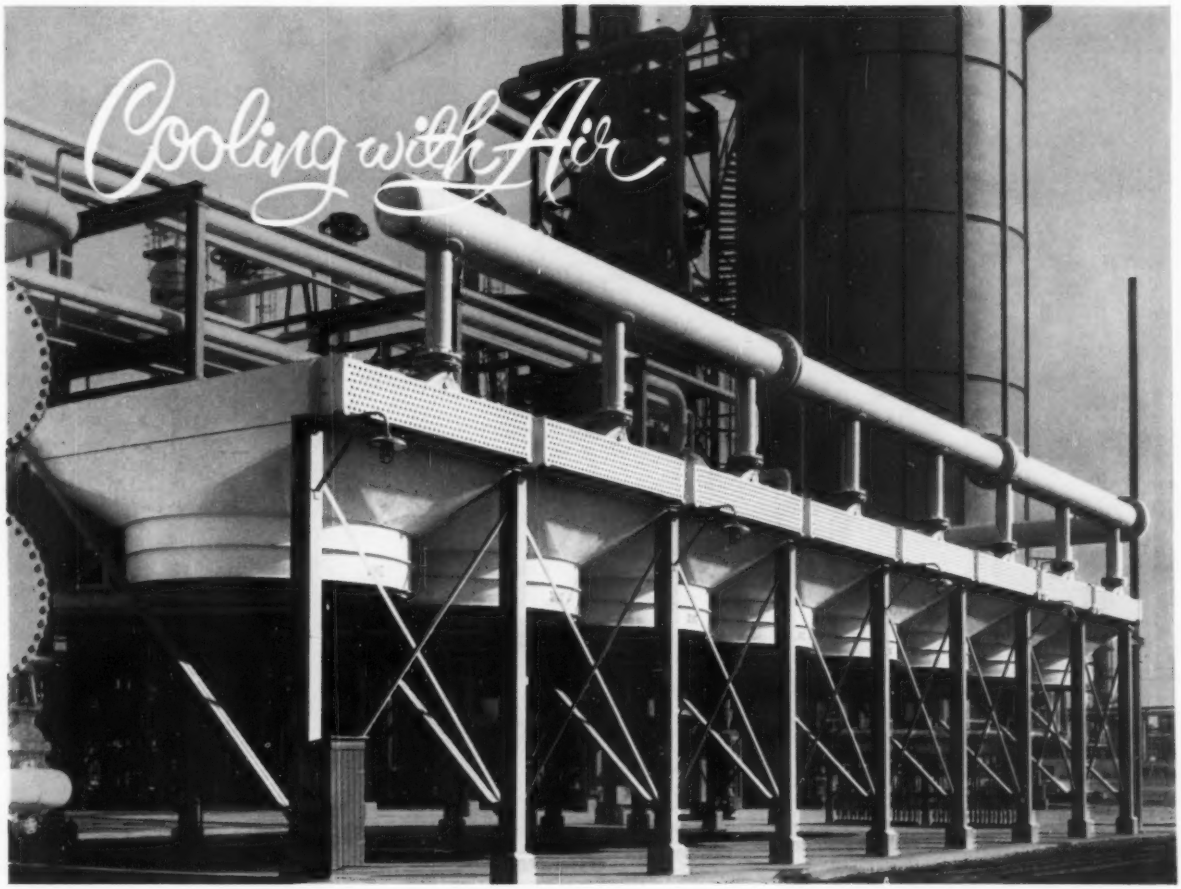
R. B. Bennett has been promoted to section head, Baytown Research and Development Division, Humble Oil & Refining Co., and has just been given a rotational assignment to serve as petroleum specialties advisor to the manager of the Manufacturing Department, Humble Division. Bennett holds a B.S. degree in chemical engineering from The University of Texas.

Bennett

J. M. (Jim) Henagan has joined Lion Oil Co. Division, Monsanto Chemical Co. as a senior petroleum engineer and has been assigned to the petroleum engineering staff, Houston. He was formerly employed by Tennessee Oil and Gas Co., Denver, Colo., and was graduated from Louisiana State University in 1943 with a B.S. degree in petroleum engineering.

Mohamed Sifat has been named chairman of the Libya Petroleum Commission. **Abubakr Izmirli, Salem Saif el Nasr** and **Hussein Belo'oun** have been appointed commission members.

For more data on advertised products, use Readers' Service Cards, last page.



IN THE BAYWAY REFINERY...

of the Esso Standard Division of Humble Oil and Refining Company.

The above pictured installation of HUDSON Solo-aire units obviated costly addition to the existent and comparatively high-maintenance-cost water system.

Over-all economic comparisons of HUDSON Solo-aire cooling versus water cooling almost invariably result in selection of Solo-aire units for much or all process cooling.

In two complete 40,000 barrel seaside refineries constructed abroad, Solo-aire units are used for ALL process cooling services. NO WATER IS USED FOR PROCESS COOLING.

In the United States in a 40,000 barrel refinery built adjacent to an unlimited water supply, 50% of the total dissipated heat is transferred directly to air through Solo-aire units.

Operating results of thousands of HUDSON Solo-aire units installed in oil, gas and chemical plants throughout the free world have established HUDSON leadership in the field of direct cooling with air.

ONLY HUDSON designs and manufactures ALL THREE categories of cooling equipment . . . for cooling solely with air (Solo-aire); for cooling primarily with air but with minimum water to obtain low effluent process stream temperatures (Combin-aire); and water cooling towers. Take advantage of HUDSON'S objective assistance in selecting the integrated cooling system which best balances capital investment and operating cost for the specific process, climatic, and water conditions.

HUDSON

ENGINEERING CORPORATION

BRAEBURN STATION • HOUSTON, TEXAS

OFFICES: 16033 Ventura Blvd. Encino, California • 122 East 42nd St. New York 17, N. Y. • 199 Bay Street Toronto, Ontario, Canada • 17 Stratton St. Piccadilly London W. 1, England • Corrientes 1115 Buenos Aires, Argen. • Rua Mexico 45 Rio de Janeiro, Brazil

WHAT'S THE HARDWARE SITUATION IN ELECTRONIC PROCESS CONTROL?

THIS NEW BOOKLET SHOWS YOU

Here, in concise, graphic form, is the whole array of Swartwout Autronic® instrumentation, industry's most comprehensive system of electronic process controls. Here is a unique presentation that shows you at a glance the diversity of equipment available to you, from sensor to actuator, for any given variable. Whether you're pondering a simple flow-control set-up or an interlocked multi-loop system, Swartwout has the hardware for the job—and this booklet will give you the specifics. To get a copy, just write for Bulletin A-913, "A Functional Guide to Autronic Control Equipment." SWARTWOUT DIVISION, CRANE CO., *Hooksett Industrial Park, Manchester, New Hampshire.*

Men . . .

B. R. Fraser, who has been manager, Manufacturing Department, Mobil Oil Co., Ltd., has been elected director of manufacturing. He succeeds **J. Blake Middleton,** who plans to retire early next year.

T. M. Martin, vice president and director, Monsanto Chemical Co., and president of Monsanto's Lion Oil Division, has retired. The name of his successor has not been disclosed.

Hamilton T. Caldwell has been elected vice president, manufacturing, Mobil Oil Co. de Venezuela. **Karl F. Madsen** and **John C. Thompson** have been named directors of the company.

Lawrence A. Kimpton has been named general manager, planning, Standard Oil Co. (Indiana). He recently resigned as University of Chicago chancellor. He will supervise long-range planning and industry and general economics.

John Moffat has been elected a director, British Petroleum, Ltd's, refineries at Llandarcy, Kent and Grangemouth, England. Moffat is a general manager in the BP Group home office for refining.

Joseph T. Froehlich, general manager, Foreign Operations Department, Texaco, Inc., has been appointed general manager of Texaco Trinidad. Froehlich, who will make his headquarters at Pointe-a-Pierre, Trinidad, succeeds **James A. Hulme.**

Donald C. O'Hara, assistant general counsel of the National Petroleum Association, has been elected general counsel of the organization. He succeeds **Fayette B. Dow,** who has been named an honorary counsel.

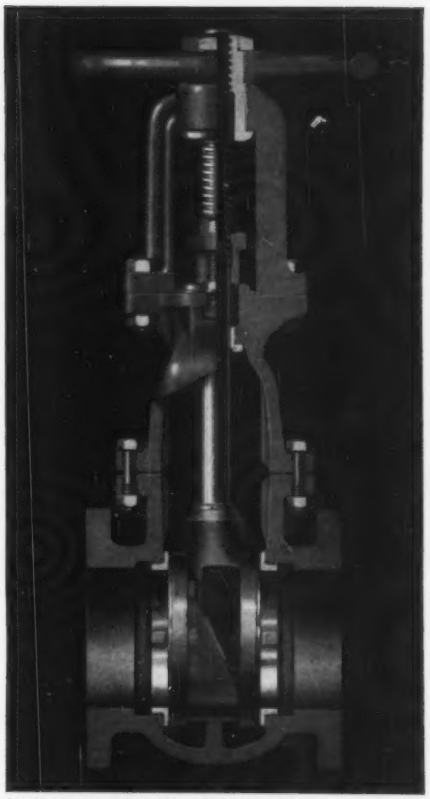
Dr. Gerald Jahoda has been appointed head of systems research and library, Technical Information Division, Esso Research and Engineering Co. He joined the company in 1957. Before that he was in charge of the technical information group, Colgate Palmolive Co.

J. Wayne Hinds has been named general manager, Vigor Oil Co., Ltd., Oshawa, Ont. Since 1956, he has been employed by Frontier Refining Co., Denver.

W. A. Knarr has joined the technical staff, Esso Research Laboratories, Baton Rouge, La. **N. C. M. Landis, J. N. Beard** and **E. W. Wald** have rejoined the staff after military service.

Thomas B. Kimball has been elected executive vice president, operations, Sinclair Oil Corp. He is being succeeded as president and chief executive officer

For severe corrosive conditions specify ALUMINUM GATE VALVES by Darling



Unique revolving disc feature assures maximum life under the most exacting service conditions. Friction between wedges is reduced to a minimum. Horizontal and vertical equalization of wedging pressure is assured.

Handling corrosive chemicals such as hydrogen peroxide, ammonium nitrate, acetic acid, concentrated nitric acid? Darling Aluminum Gate Valves give you longer life, cut maintenance costs, under these and other severe service conditions. Here's why:

Darling metallurgical engineers have thoroughly tested and standardized on the most highly corrosion-resistant aluminum alloys in use today.

Accurate casting control and precision assembly reduces friction and wear, provides maximum ease of operation.

Darling Double Disc Parallel Seat principle assures freedom from leakage, trouble and downtime.

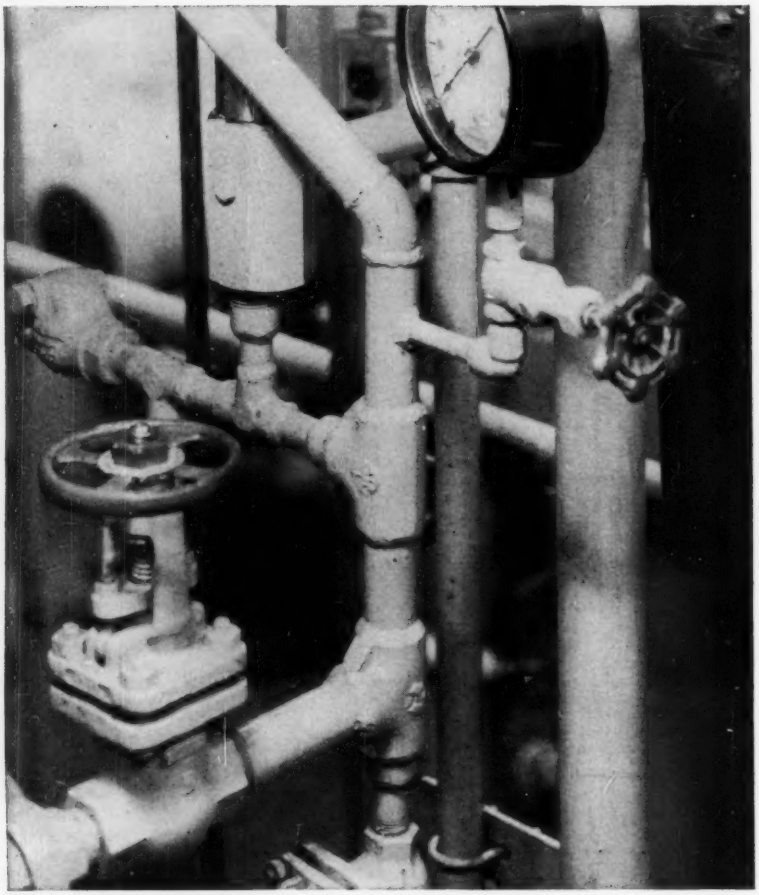
Darling aluminum alloy valves are available in sizes from ½" through 24". Write us about your requirements and service conditions.

DARLING VALVE & MANUFACTURING CO.

Williamsport 31, Pa.

Manufactured in Canada by
Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.

For more data on advertised products, use Readers' Service Cards, last page.



Forged stainless steel 150 lb. socket weld W-S Fittings on tank piping at E. R. Squibb & Sons plant, New Brunswick, N. J.

To Beat Corrosion's Bite

—W-S FORGED 150 LB. STAINLESS FITTINGS

They're ideal for standard pressure services (300 p.s.i. cold, non-shock and 150 p.s.i. steam pressure) requiring corrosion resistance or toughness at low temperatures.

But maybe your next installations call for forged aluminum fittings, or forged carbon steel fittings, or forged stainless and alloy fittings for higher pressures. W-S specializes in designing and making them all to top standards of safety and high strength . . . with outstanding resistance to shock, heat, vibration.

For specifications and distributor locations, write *Forge & Fittings Division, H. K. Porter Company, Inc., Box 95, Roselle, N. J.*

FORGE AND PORTER **FITTINGS DIVISION**

H. K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.

Men . . .

of Sinclair Refining by **C. J. Allen.** Allen has been a vice president of the parent company since 1957.

J. D. Stetson Coleman has been elected a director of Universal Oil Products Co. He replaces **Carl S. Miner,** who resigned. Coleman is also a director of Zapata Oil Co.

C. E. H. Verity has been named to the board of directors of Foster Wheeler Corp. He is managing director of the corporation's subsidiary, Foster Wheeler, Ltd., London.

A. Allan Bates, vice president, research and development, Portland Cement Association, Chicago, has been elected president, American Society for Testing Materials. He will serve a one-year term.

Cyril O. Rhys has been appointed a senior engineering associate, Esso Research and Engineering Co. He was formerly an assistant director in the firm's Design Engineering Division. He joined Esso Research in 1938.

Robert M. Dickey has been appointed a senior patent attorney for Monsanto Chemical Co.'s Research & Engineering Division, Everett, Mass. He has been a patent attorney for the company's Plastics Division, Springfield.

Alfred W. Andrews Jr., has been appointed associate director of engineering for Monsanto Chemical Co.'s Plastics Division, Springfield, Mass. He was assistant director, Engineering Department.

Dr. William C. Hammann has been appointed a research group leader at Monsanto Chemical Co.'s Research & Engineering Division, Dayton, Ohio, after serving as a research specialist there.

Douglas C. Atkins has joined the Engineering Department, Monsanto Co.'s Organic Chemicals Division, St. Louis, Mo., after serving with the U. S. Army Corps of Engineers.

Spence T. Taylor has been appointed president of Mobil Oil de Venezuela. He previously served as executive vice president of the company. Taylor replaces **Dr. James A. Tong,** who will continue as an advisor with the firm until his retirement January 1.

E. Paul Ludman, treasurer of Signal Oil & Gas Co., has been elected a vice president of the company.

For more data on advertised products, use Readers' Service Cards, last page.

SHOCK OVERLOADS can't damage the mixer drive. In gear-drive models, GripSpring assembly between gear and drive shaft lets gear slip if overloaded more than 50%. It's a safety feature you never could get before in a portable mixer.

NEW MIXER

Get set to topple some traditions in fluid-mixing ease and economy

You won't have to lubricate it for five years.

Overloads can't hurt the gear drive.

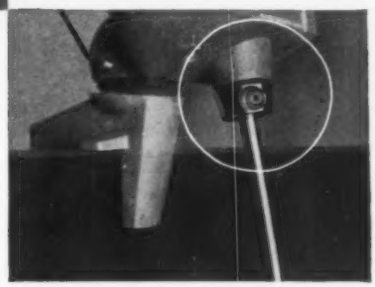
It comes with a chemical plant motor as *standard*, at no extra cost.

You don't need three hands to remove the shaft.

And it mixes fluids like no portable mixer you've ever seen. Delivers up to 45% more fluid flow in gear-drive models . . . higher impeller head in direct-drive models. Actually lets you handle many mixing jobs with a *smaller* mixer drawing *less power.*

That's just a sampling of the new LIGHTNIN Portable Mixer. It has been tested under every conceivable condition of use and load. It's ready—in sizes from ⅛ to 3 hp, gear drive or direct drive. And the price is right.

Your LIGHTNIN Mixer representative will be glad to show you why you can use it to mix fluids better—and at lower cost—than ever before. You'll find him listed in Thomas' Register and in the yellow pages of your telephone directory. Call him today. Or write us for descriptive Bulletin B-520.



SAVE COST of a corrosion-resistant alloy with this shaft chuck. It's way up out of the tank—always above liquid level. It's simple, quick-acting. Tighten one screw, and shaft is locked—can't come loose unless you want it to.

NO MYSTERY about the right mixer angle for best mixing. Vertical and horizontal indexing makes it a snap to describe the right setting so everybody understands.

IN FIXED MOUNTINGS, TOO. Get the same all-new advantages in permanent-mounting LIGHTNIN Mixers for open and closed tanks. A complete line, sizes from ¼ to 3 hp. For details on these, send for Bulletin B-521.

Lightnin® Mixers

MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 164-k Mt. Read Blvd., Rochester 3, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Avenue, Toronto 19, Ont.

Suppliers Notes...

GROVE VALVE AND REGULATOR CO., Oakland, Calif., has named **Claude W. Brown** sales and technical service representative for Oklahoma and Kansas. Brown has been with the gas and petroleum equipment industry for the past 22 years. Most recently he was a refinery sales representative for Oil Capitol Supply Co., Tulsa. Before that he was with Orbit Valve Co., also of Tulsa, as a division sales manager in charge of the Oklahoma, Kansas, Texas Panhandle and Eastern Nebraska territories.

Brown

SIVYER STEEL CASTING CO., Milwaukee and A.P.V.-Paramount, Ltd., Crawley, England, have reached a licensing arrangement whereby A.P.V., a subsidiary of the A.P.V. Co., Ltd., is to manufacture and sell Sivyer refinery fittings in Europe and the British Commonwealth. These refinery fittings, manufactured in carbon, low, medium and high-alloy steels, include return bends, corner and terminal fittings, multiple hole headers, etc.

W. S. SHAMBAN & CO. has elected **Carl Wolff** vice president of sales. Wolff has been with Shamban since 1957, having worked for National Seal Division before. Since joining Shamban, he has served as Western Regional sales manager and general sales manager. He will headquarter in Culver City, Calif.

UNION CARBIDE DEVELOPMENT CO., division of Union Carbide Corp., has named H. C. Sharp Co., St. Louis, Mo., and Master Products Co., Chicago, Ill., sales representatives for ULOK cube air filters.

U.S. INDUSTRIES, INC., has elected **I. John Billera** executive vice president, operations. He was previously senior vice president of the company. He joined U.S. Industries as treasurer in 1955. He was controller and assistant treasurer, Noma Electric Corp., was with Edward Ermold Co. and the Sperry Gyroscope Co. before coming to U.S. Industries. Billera graduated from the College of the City of New York.

Billera

FAIRBANKS, MORSE & CO. has appointed **Alfred C. English** general manager, Compressor Division. When English joined Fairbanks Morse in April 1957, he was assigned to the staff of the vice president, engineering, to coordinate the product planning for the company's rotary compressor.

CONSOLIDATED SYSTEMS CORP.'s vice president and general manager, **Harry E. Burke, Jr.,** has been named a delegate to the 1961 International Measurements Conference to be held next summer in Budapest, Hungary, by the Instrument Society of America.

BENDIX CORP.'s Bendix Filter Division has appointed **Albert N. Beswick** Eastern Regional sales manager. In his new position, Beswick will maintain offices at the division's main plant, Madison Heights, Mich. He was formerly sales engineer for the division in the middle Atlantic states.

E. W. BLISS CO. has elected **Robert Potter** chairman of the board of directors, and **J. Ralph Patterson** president and chief executive officer. Potter was previously president of the company and Patterson was formerly vice president in charge of the firm's Mackintosh-Hemphill Division. Patterson was also elected a director of the company.

Potter

Patterson

CATAWISSA VALVE & FITTINGS CO. has elected **Craig L. Davis** president. Davis joined the company in 1946 as plant engineer, following service in World War II as a U.S. Air Force pilot. Before joining Catawissa, he was with the Hydraulics Division, Glenn L. Martin Co., Baltimore.

GRAYBAR ELECTRIC CO., INC., has appointed **B. G. Draper** operating manager, Corpus Christi, Texas. Draper started with Graybar in New Orleans, La., as a packer in 1953. Two years later he was placed in sales.

SOLAR AIRCRAFT CO. has named **Morris Sievert** manager of turbomachinery sales. Sievert has been in turbomachinery sales with Solar since 1957. Prior to joining Solar, he was district territory sales manager for Elliott Co. He holds a B.S. degree in mechanical engineering from the Missouri School of Mines and Metallurgy. In his new post, Sievert will manage sales of Solar's gas turbine engines, compressors and related equipment.

Sievert

GENERAL ELECTRIC CO. has named **W. W. Smith** manager, Distribution Assemblies Department, California plant. Smith has been manager, commercial engineering at the California plant for two years. He joined General Electric as a test engineer in 1946.

UNION PUMP CO. has signed a contract with Kinoshita and Co., Ltd., Tokyo, to market Union pumps in the Far East. The contract names Kinoshita exclusive sales and service representative for Japan and 13 other Far Eastern areas.

SOLAR AIRCRAFT CO. has promoted **Robin Schmidt** to director of public relations and advertising. Schmidt joined Solar in the Public Relations and Advertising Division in 1957. Prior to that he was a public relations man with Pacific Finance Corp.

GENERAL REFRACTORIES CO. has appointed **George R. Rittenhouse** treasurer and **John E. Hartshorn** secretary. Rittenhouse, who joined the firm in 1951, was formerly assistant treasurer. Hartshorn was previously assistant secretary.

ROY F. WESTON, INC., has named **Ernest R. Roth** head of the Research, Development and Consulting Division. Roth was with The Atlantic Refining Co.'s industrial wastes engineering section before joining Weston, Inc. He will make his headquarters at Newton Square, Pa. Roy F. Weston, Inc., specializes in industrial water pollution control, air pollution control and water supply.

Roth

SALTY STORY – To supply its constant needs for great quantities of cooling water, Tidewater Oil Company's Delaware refinery taps a tidal river for a maximum of 360,000 gpm. Salinity runs as high as 30,000 ppm, so Ni-Resist valves are used because of their excellent resistance to corrosive attack.

Corrosion by cooling water tamed by Ni-Resist irons

Corrosion is a major menace to any refinery – but it poses an *additional* problem to some.

These are refineries that have little choice in the way of cooling water. Many coastal plants operate with water that is salty enough to eat the heart out of pumps, pipes, valves and other equipment in short order.

A neat way to put the Indian sign on such corrosive water is through the use of Ni-Resist* irons, a group of high-nickel alloy cast irons containing sufficient Nickel to produce an austenitic metal structure as well as a complete change in the chemical and physical characteristics.

The range of applications of Ni-Resist irons in corrosive service is broad. Their dependability has been well proved for valves, valve stem bushings, fittings, pump parts and other items of refinery equipment.

No other cast metals provide such a unique combination of useful engineering properties:

- **Corrosion resistance greater than that of unalloyed or low alloy cast irons and steels**
- **Excellent resistance to cavitation erosion**
- **Wear resistance**
- **Heat resistance**
- **Low temperature stability**
- **High order of castability . . . . . machinability . . . weldability**

No brief message such as this could possibly cover *all* the advantages of Ni-Resist irons. Nor can it detail their excellent resistance to destructive attack by corrosive crudes, salt water and refinery corrosives. We have an informative and valuable 70-page illustrated booklet that tells lots more. Called *Engineering Properties and Applications of Ni-Resist Irons,* it's free on request and well worth having. Write for a copy *today.*

*Registered trademark

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street INCO New York 5, N. Y.

NI-RESIST

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

TRINITY STEEL CO., INC., has appointed Cudmore Supply Co. sales representative for the metropolitan New York City area. Allred Co., Atlanta, Ga., has been named Trinity Steel's sales representative for Alabama, Georgia, Tennessee, North and South Carolina.

THOMAS C. WILSON, INC., has elected **Mrs. Martha A. Wilson** chairman of the board of directors. **O. J. Bagnoli** has been named president of the company, and **Alexander John** has been appointed vice president. Mrs. Wilson was formerly president of the firm. Bagnoli was vice president and general manager and John sales manager and assistant general manager.

KEASBEY & MATTISON CO. has appointed **John F. Simons, Jr.,** employment manager, Personnel Department. Simons graduated from Germantown Friends' School and Princeton University.

OAKITE PRODUCTS, INC., has named **Daniel P. Brennan** technical service representative, New York City. Brennan has been on Oakite's technical service laboratory staff since 1957.

A RECORD CLIMBING TO THE TOP

the KEMCO code / ***THOROUGH QUALITY CONTROL INSPECTION***
SPECIFICATIONS MATCHED EXACTLY
DELIVERY WHEN PROMISED

We'd like to furnish you more information. Please write today for illustrated brochure and additional data on personnel, facilities and customers to:

KRUEGER ENGINEERING & MANUFACTURING CO.
12001 HIRSCH ROAD • HILLCREST 2-2537
P. O. BOX 11286 • HOUSTON 16, TEXAS

Representatives:

ENGINEERED PROCESS EQUIPMENT CO.
774 E. Green • MU 1-6663 • Pasadena, Cal.
Offices in Oakland
TEmplar 2-5391

JOE KLIPPER
P. O. Box 3266
TE 3-1879
Beaumont, Texas

REX BIRCKET
424 So. Cheyenne
LU 4-6651
Tulsa, Okla.

COOPER-BESSEMER CORP. has appointed **M. J. Helmich** chief engineer, Development Division. He will fill the position vacated by **W. R. Crooks** who retired August 4, after more than 25 years in the heavy duty diesel and gas engine development field. Replacing Helmich as assistant chief development engineer will be **G. A. Dorton.** Crooks will continue with the corporation in the capacity of development consultant.

Helmich

Crooks

Dorton

NORTON CO. has appointed **K. Dale Swanson** abrasive engineer for the southwestern section of Los Angeles County. He was formerly field engineer in the company's Pacific Coast district office. **John M. Nelson** has been named field engineer, Chicago district office. He recently completed a sales training course at Norton.

ANSUL CHEMICAL CO., Marinette, Wis., has named **Robert W. Reinicke** vice president of operations. He was with Ekco Products Co., Chicago, before joining Ansul Chemical. He has also been a plant manager for Chase Brass and Copper Co.

THE GOODYEAR TIRE & RUBBER CO. has appointed **D. H. Francis** manager of all chemical products production. Francis, now general manager of Goodyear Atomic Corp., Portsmouth, Ohio, will assume his new duties January 1, 1961. **G. H. Reynolds,** who has been manager, Production Division, Goodyear Atomic Corp., will replace Francis.

GENERAL MILLS., INC., has named **James H. McGarry** director of manufacturing for the Mechanical Division. McGarry has been in electronic and electromechanical manufacturing since 1935. He attended Armour Institute majoring in industrial engineering.

TUBE TURNS PLASTICS, INC., has elected **J. P. Knopf** a vice president. Knopf has been secretary and treasurer since the

For more data on advertised products, use Readers' Service Cards, last page.

The pump must match the application

The available range of our RPK Process Pumps offers the Oil Industry a selection that fully meets the fundamental requirement stated above.

The special characteristics of this pump are maximum reliability and economical operation at all operating points. Other features are the wide range of capacities and applications, the ease with which erection and disassembly can be carried out, and parts subject to wear renewed. The design includes a high factor of safety.

The parts particularly liable to deteriorate by wear are standardized for the widest possible range of sizes, and thus the maintenance of an adequate stock of spares is greatly facilitated.

Every type of service is catered for in respect of shaft sealing, which may be by means of the conventional packed stuffing-box or one of a great variety of mechanical seals.

KSB

Klein, Schanzlin & Becker Aktiengesellschaft, Frankenthal (Pfalz) Germany

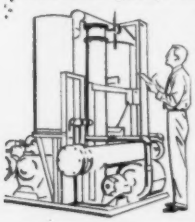
For more data on advertised products, use Readers' Service Cards, last page.

Carl G. Paulson,
Director of Hayes Research and Development Group, Reports...

NEW NITROGEN POTENTIALS

Assume you face the need for high purity nitrogen at a low per-unit cost figure. You want to use it as a heat treating atmosphere . . . or as a "blanket" for hydrocarbons or food products . . . or for any one of a number of industrial applications. How can you bring this safe, inert gas out of the lab and into general use without inflating your costs?

Our R & D group reasoned that a low cost generator was the logical solution and followed up and developed a completely new piece of equipment—the C. I. Hayes "Nitro-Gen." This unique combination of stationary retort and cyclical programmed dryer has cleared the way for production of 99.99% pure inert gas at approximately 20c per thousand cubic feet.



The immediate benefits of low cost nitrogen as a protective heat treating atmosphere were revealed in initial metallurgical applications. For example, test bars of Type C-1141 Carbon Steel were subjected to routine hardening under (1) nitrogen, (2) dissociated ammonia, and (3) endothermic gas atmospheres—each test followed by routine oil quench and tempering. Hardness results from these tests proved identical . . . but a substantial boost in toughness showed up in the bars treated under nitrogen. The nitrogen atmosphere produced 100% greater toughness, according to a transverse break test.

Safety alone makes nitrogen worthy of careful consideration. If this non-combustible gas can be produced efficiently and economically (and we're doing it!), Hayes R&D Engineers believe its potentials are virtually limitless.

Blanketing operations are No. 1 prospects for the Hayes Nitro-Gen . . . in *food, paint, petroleum, chemical,* and *petrochemical* industries . . . where low cost per cubic foot of produced gas means fast pay-back on the job.

We'll gladly demonstrate the Nitro-Gen in our lab or send technical literature if you desire. Request Bulletin 5901-NI.

Linde MOLECULAR SIEVES UCC

Designed in conjunction with Linde Company . . . to utilize Linde Molecular Sieves

Established 1905

C. I. HAYES, INC.

853 WELLINGTON AVE. • CRANSTON 10, R. I.

Whatever the job, **it pays to see HAYES** for metallurgical guidance, laboratory facilities, furnaces, atmosphere generators, gas and fluid dryers.

Suppliers . . .

company was organized in 1954. He worked as assistant controller for Girdler Corp. before joining Tube Turns Plastics.

CELANESE CORP. OF AMERICA has appointed **James W. Flynn** vice president and director of marketing. Flynn has been general sales manager of Celanese Plastics Co. since July 1959. He received a B.S. degree from Canisius College in 1939.

BELL & HOWELL INTERNATIONAL DIVISION has appointed **Albert W. Brandmaier** director, Consolidated Electrodynamics Corp.'s international operations. Brandmaier was formerly director, CEC's International Department. He joined the firm in 1954 as an engineer in the Systems Division.

ATLAS VALVE CO. has appointed **Harry McPherson** sales representative in Kansas, Iowa and Nebraska.

KEASBEY & MATTISON CO. has named **John R. Wilson** plant manager, Ambler, Pa., plant. Wilson was previously with Link-Belt Co. He attended Drexel Evening College.

AMERICAN METER CO. has appointed **Edmund B. Lennig,** sales representative for the San Francisco sales district. Lennig recently completed American Meter's gas measurement school, Erie, Pa., and is a graduate of Stanford University.

CAMBRIDGE WIRE CLOTH CO. has extended its sales territory into the following New England areas: Massachusetts, Rhode Island, Maine, New Hampshire, Vermont and Northern New York.

DIAMOND ALKALI CO. has elected **W. A. Crichley** treasurer, and named **R. H. Armor** controller. Crichley formerly was the controller and Armor has been the treasurer. **R. K. Buettner,** formerly assistant controller, was elected assistant treasurer, and **P. J. Joyce** was named assistant controller.

UNIVERSAL OIL PRODUCTS CO. has named **Robert H. Carlton** product sales representative. He will serve the Midwest, operating from the Chicago area. Before joining UOP, he was with Allied Chemical Co. in Canada.

AMERICAN POTASH & CHEMICAL CORP. has appointed **John R. Jones** New York-New England district sales manager. Jones will continue to headquarter out of the firm's Eastern general sales offices, New York.

LEHIGH FAN AND BLOWER DIVISION, Fuller Co., has named **W. A. (Bill) Crowder** to handle sales engineering and customer service. Crowder's territory includes central and western Washington and Alaska.

MOTOROLA, INC., has named **Robert H. Davis** chief engineer of its Microwave Department. In this capacity, he is responsible for microwave product development, systems engineering and field engineering. Davis has been with the Microwave Department since graduating from the University of Minnesota in 1950. He served as a field project engineer for four years, then was appointed manager of microwave systems engineering in 1954. In 1958 he assumed the additional responsibilities of microwave publications.

Davis

ALLIED CHEMICAL CO.'s General Chemical Division has named **James W. Kelley** sales manager for basic industrial chemicals. Kelley, with the division 13 years, has served as manager of Chicago and Buffalo sales offices prior to coming to the New York headquarters as assistant sales manager in 1959. **William E. Houghton** has been appointed a sales manager. He has been with the division for 27 years. He will also sell basic industrial chemicals.

Kelley

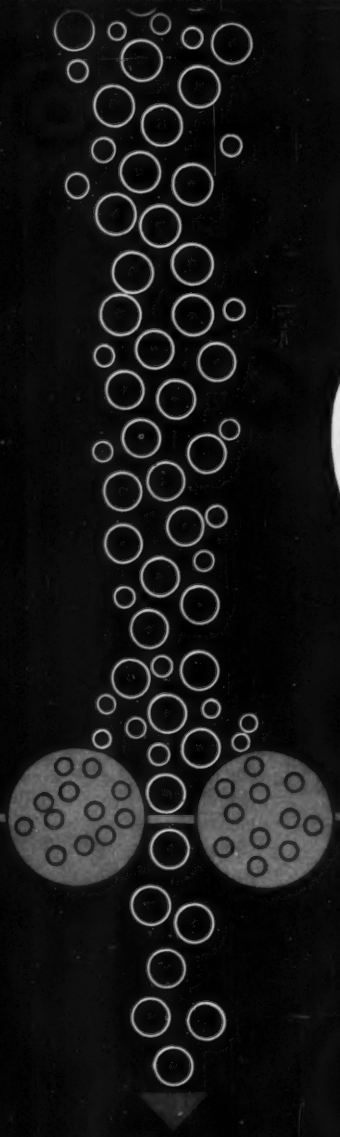
Houghton

AIR PRODUCTS, INC., has elected **Dr. William A. Bain** vice president. Dr. Bain was formerly executive vice president of Vitro Laboratories. He will be in charge of the company's missile and rocket programs.

ATLAS VALVE CO., has appointed the Rains Co., Salt Lake City, a sales representative. The Rains Co. will represent Atlas in Utah, Montana, Southern Idaho and Eastern Nevada.

COPPUS ENGINEERING CORP. has named Werlla and Co., Houston, a district sales representative. Werlla and Co. will cover sales for the entire Southeastern area of Texas.

CARPENTER STEEL CO.'s Alloy Tube Division has appointed **Arvin W. Harrington** manager of distribution. He was formerly Eastern Regional sales manager for the



Major refiners report:

IMPROVED DRYING AND PURIFICATION

...WHEN YOU ADSORB WITH LINDE MOLECULAR SIEVES

This is only one of many applications which utilize the high capacity and selectivity of LINDE Molecular Sieves. In fact, Molecular Sieves not only outperform other adsorbents, but do other adsorption jobs never before accomplished. Whether in new installations or as replacement adsorbent in existing units, Molecular Sieves can help you minimize both investment and operating costs. More specifically, here's how they are used. . . .

A major petrochemical company has reduced the CO_2 con ent of its ethylene from 3000 PPM to less than 1PPM. This high purity is achieved in a single-stage process, automatic and non-corrosive, which has proved to be more economical than the alternative four-stage process. Other petrochemical uses include drying of cracked gases, ethylene, hydrogen, liquid propylene, solvents and many other gases and liquids. **Natural gas producers** use Molecular Sieves for drying and sweetening of natural gas, for sweetening of liquid propane and butane, and for drying of adsorber oil. **Petroleum refiners** use them to gain efficiency in drying reformer hydrogen, liquid butane LPG and transformer oil, and for removal of impurities such as CO_2 and mercaptans **Refrigeration manufacturers** use Molecular Sieves as a desiccant in super-drying refrigerants to eliminate freeze-up and corrosion.

For these and many other adsorbent applications, you can rely on patented LINDE Molecular Sieves to perform more effectively. They are the top quality material of their kind available today, always uniform, with high capacity, high strength, and high bulk density. They are available in regular and special grades to meet your specifications.

LINDE technical know-how—gained from years of laboratory and field work with adsorption problems—can help make Molecular Sieves work profitably for you. For further information, write: Dept. PR-10, Linde Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. **In Canada:** Linde Company, Division of Union Carbide Canada Limited, Toronto 7, Canada.

SOME AREAS WHERE MOLECULAR SIEVES IMPROVE ADSORPTION

- Purification of ethylene
- Drying gases, liquids, solvents
- Drying, sweetening natural gas
- Sweetening liquid propane, butane
- Drying jet fuels
- Octane improvement
- As refrigerant desiccant
- Controlled atmosphere purification

LINDE COMPANY

UNION CARBIDE

"Linde" and "Union Carbide" are registered trade-marks of Union Carbide Corporation

A man who's out to make a name for himself and his company – makes it a habit to read his businesspaper regularly and thoroughly. You know there's no surer way to keep abreast of what goes on in your trade or industry. No richer source of useful, usable ideas for getting ahead in your job, or in your field – than the advertising and editorial pages of . . . your businesspaper.

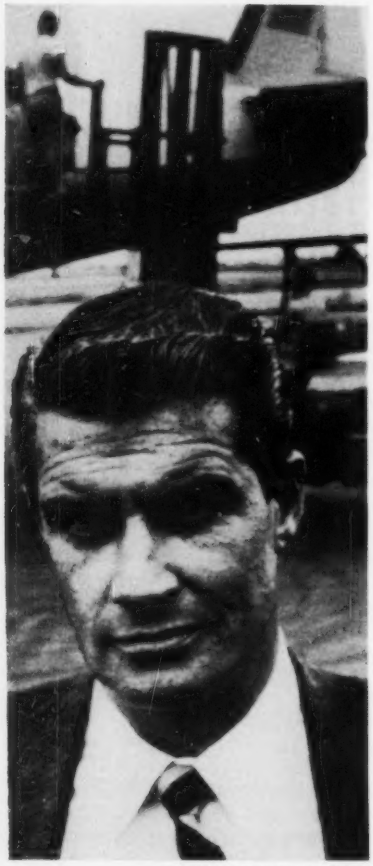


PHOTO ON LOCATION BY EHRENBERG

Where there's business action, there's a businesspaper

. . . everywhere in the Hydrocarbon Processing Industry, there's . . .

PETROLEUM REFINER

One of a series of advertisements prepared by the ASSOCIATED BUSINESS PUBLICATONS

Suppliers . . .

division. **Harry A. Hauser** succeeds Harrington as Eastern Regional sales manager.

TURBOCRAFT, INC., has named **Frank A. Mondok** vice president. **C. N. Hollwedel** has been appointed senior project engineer. Mondok joined Turbocraft in 1957 as a senior design engineer and moved to manager of engineering in 1959. Hollwedel recently joined the firm.

ELION INSTRUMENTS, INC., has completed a 3,500-square-foot addition to one of its two Bristol, Pa., facilities.

MINNEAPOLIS-HONEYWELL REGULATOR CO. has appointed **Kenneth Brierley** general manager, Fall River, Mass., Industrial Products Group Division. **John H. Hagen** succeeds Brierley as head of the Rubicon Division. Brierley joined Honeywell's Brown Instruments Division in 1946. Hagen has been with the company since 1933.

HEYDEN NEWPORT CHEMICAL CORP. has transferred **Jerome T. Kratina** from the New York area to the northern and central New Jersey territory as a sales representative. Kratina has been with Heyden since 1939 in sales and supervisory capacities. Before joining the Sales Department in 1954, he was assistant to the general sales manager and administrative assistant to the comptroller.

EVER-TITE COUPLING CO., INC., has expanded its office space in New York City to enable its customers to individually discuss their special coupling requirements with Ever-Tite's sales and engineering departments.

HILLS-McCANNA CO. has named Harry W. Taylor Co., Detroit, and A. P. Engelhart Co., Flint, Mich., stocking distributors for ball valves and diaphragm valves.

UNIVERSAL OIL PRODUCTS CO. has named **Thomas M. McLoughlin** product sales representative. He will service the Eastern Seaboard states, operating from Philadelphia. Before joining UOP, he was with Wabash Chemical Co.

U.S. INDUSTRIES, INC., has elected **T. Singelis** vice president, marketing services, Clearing Division. Singelis was advertising manager, Clearing Machine Corp., Chicago, from 1952 until shortly after that company was acquired by U.S. Industries in 1954.

CALUMET & HECLA, INC.'s, Wolverine Tube Division has appointed **F. J. O'Donnell** sales representative. He was formerly with United Wire and Supply Co.

NORTON CO. has appointed **James E. Haggett** supervisor, Industrial Engineering Department. **Marshall W. Greene** has been named supervisor, Manufacturing Control Department, crushing plants. **Alan F. Howe** has become head of the company's Process Engineering Department, crushing plants.

H. K. PORTER CO., INC., has named **W. D. Fullerton** general manager, Forge & Fittings Division. Fullerton has been with Porter since 1957, and prior to his new appointment, was assistant general manager, Refractories Division.

THE PERMUTIT CO. has appointed **M. E. Gilwood** director of development. **Dr. C.**

Gilwood

Calmon

Calmon has been named director of laboratories to succeed Gilwood. Dr. Calmon will also continue to supervise the chemical laboratories for Permutit.

WOLVERINE TUBE DIVISION has appointed **Carl T. Fuller** manager of special product sales. Fuller joined the company in 1947 as a time study engineer and since then has served the firm in various field sales capacities. His most recent assignment was that of sales manager, Chicago district. He will make his headquarters at the division's administrative office, Allen Park, Mich.

Fuller

COOPER-BESSEMER CORP. has appointed **Harvey B. Cox, Jr.,** sales engineer in the Houston branch office. Cox was formerly with the Clark Bros. Co., Houston. He is a petroleum engineering graduate of the University of Houston.

CLAYTON MARK & CO. have promoted **William J. Dickman** assistant sales manager of the Union Division. Dickman has been with the company since 1945 and has been a district sales manager in the division for the last several years.

THE BABCOCK & WILCOX CO.'s Boiler Division has appointed **Robert V. Mourer** district service engineer for the Denver sales district. He joined B & W in 1948 after graduation from Purdue University, where he earned a degree in mechanical engineering.

Suppliers . . .

KAISER STEEL CORP.'s Fabricating Division plants, Napa and Fontana, Calif., have appointed **Graeme D. Plant** and **John A. Shackleton** to management positions. Plant has been named manager of engineering and Shackleton has been promoted to assistant manager of engineering.

DELTA TANK MANUFACTURING CO., INC., has named **Charles H. Maddox** to the Sales and Service Department, Laurel, Miss.

GENERAL RUBBER CORP. has appointed two sales representatives in the New England area. Gil Moore & Co. will service Maine, Massachusetts, New Hampshire, Rhode Island and Vermont. Joseph G. Stalb Co. will handle sales in Connecticut.

Test Yourself

(Answers to Quiz on Page 186)

CASE NO. 1

Arbitrator Harry Seligson ruled: "The employer has the right to use his premises as he sees fit unless he has contracted away that right. The clause prohibiting distribution of political or economic literature on company property pertains to union bulletin boards and cannot be construed as a limitation on management. Grievance denied."

CASE NO. 2

Arbitrator B. Meredith Reid ruled: "Arbitrators, as a general rule, will not permit management to use demotion as a form of discipline unless the agreement specifically provides for such—for to do so would abridge the senority rights granted by the contract."

CASE NO. 3

Arbitrator B. Meredith Reid ruled: "A coffee break is essentially a rest period—a break from the pattern of work—a ceasing of doing what you were doing. The time allowed is to enable the employe to withdraw from labor or exertion for the obvious advantage to the company and the individual of recharging the human physical and mental storage battery. The company is obligated to restore and continue the practice as heretofore carried out, of allowing coffee breaks for the remainder of the contract —unless the practice is changed by MUTUAL consent."

Petroleum Refiner Classified Ads

RATES: **Regular Classified** (undisplayed) set in this type: 20 cents per word. Minimum charge, $4. Blind box address in our care counts six words. Replies forwarded without charge. **Display Classified ads,** set in suitably larger type with ruled border $13.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All Classified ads payable in advance.** Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston 1, Texas.

MISCELLANEOUS

Manuscripts Wanted

Have you written a book you would like to have published? Do you have an idea or an outline that you would like to talk over with a publisher? Gulf Publishing Company, publishers of World Oil, Petroleum Refiner and Pipe Line Industry magazines, and numerous technical books, is actively seeking trade and technical manuscripts for publication by its rapidly expanding Book Division. For further information write to Manager, Book Publishing, Gulf Publishing Company, P. O. Box 2608, Houston 1, Texas.

■ IMPORT QUOTA—We seek Coastal Refiner wanting 1961 quota available now on contract. Bonus $1.10 level. Box 4803; Midland, Texas. Houston, Texas.

HELP WANTED

SENIOR PROCESS ENGINEERS

Permanent employment with an expanding company. Excellent advancement opportunities for men with at least 10 years experience in process design of petroleum and petro-chemical plants.

Send detailed resume to:

G. VICTOR HOPKINS

Arthur G. McKee & Co.

2300 Chester Ave. Cleveland 1, Ohio

FOREIGN REFINERY MANAGER

Prefer degree, but not required.
Also have openings for:
Refinery Superintendent and
Shift Foremen.

KEY PERSONNEL

Room 405 711 Main Street
Houston 2, Texas

METALLURGICAL ENGINEER

The Chemstrand Corporation's nylon manufacturing plant at Pensacola, Florida is seeking a graduate engineer to assist the chief metallurgist in shop problems relating to materials selection, welding, and heat treatment. Experience with chemical processing equipment desired.

Excellent working conditions and benefit programs. Attractive community life and living conditions in Gulf Coast location.

Send resume of academic training and experience to:

Manager, Employment-Recruitment: BOX P-3
THE CHEMSTRAND CORPORATION
DECATUR, ALABAMA

HELP WANTED

■ YOUNG CHEMICAL engineer with at least five years refining experience to learn tray designing. Must be good at math. Koch Engineering Co., Inc., 321 West Douglas, Wichita, Kansas.

■ ENGINEER OF ABILITY and pleasing personality to help in development and sale of glass epoxy pipe. Address your replies to Koch Engineering Co., Inc., 321 West Douglas, Wichita, Kansas.

FOR SALE

HIGH PRESSURE VALVES —USED— EXCELLENT CONDITION

11 Crane motor operated gate valves 12", Limited Torque, Catalog 83½-U, Disc and Seat HF, Pressure 1000 lbs., Temperature 900°, Weld-On Type, Body WC 1S, Stem CR-13.

3 Edwards hand operated globe valves 12", Figure 3505-Y, Disc and Seat HF, Pressure 1500 lbs., Temperature 950°, Weld-On Type, Body #1703, Stem CR-13.

Approx. 150 Crane, Edwards, and Hancock Carbon Moly Welding Valves, ½" to 6", 1200 to 1500# Pressure, 900° F.

T. B. Rees
Kennecott Copper Corp.
Kearns Bldg., Salt Lake City, Utah

PUMPS

Designed • Built • On Hand

Afton Pumps:
VERTICAL PROCESS
VERTICAL SUMP
PROPORTIONING
VERTICAL COOLING WATER
HORIZONTAL CENTRIFUGALS

Gorman-Rupp Pumps:
SELF-PRIMING
SOLIDS HANDLING
DIAPHRAGM

U. S. Pumps:
BARGE STRIPPING
SUBMERSIBLES
AXIAL FLOW

RECONDITIONED PUMPS AND PUMPING UNITS OF ALL TYPES IN STOCK

Write or phone for literature and additional information

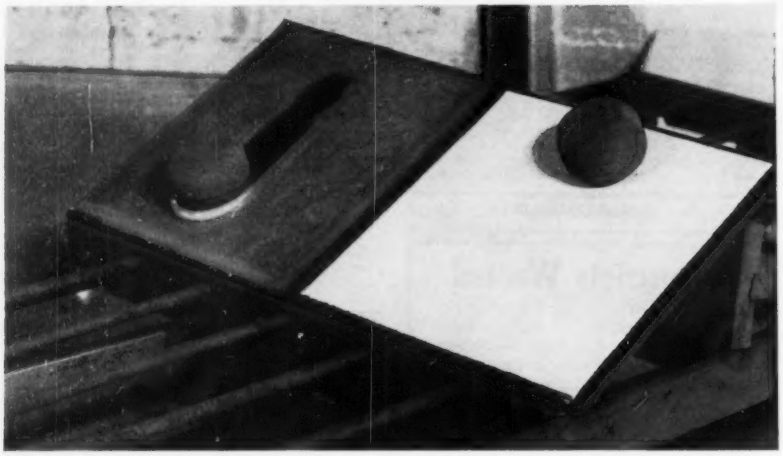
7335 AVENUE "N" • P. O. BOX 9234
TELEPHONE: WAlnut 3-9751

Afton ENGINEERING INC. HOUSTON, TEXAS
Pump Specialists

■ OLIVER CONTINUOUS VACUUM PRECOAT FILTER, (New-Unused) 5'3" dia. x 10'. Face, Monel Construction. Write Box 341-R, PETROLEUM REFINER, Houston, Texas.

For more data on advertised products, use Readers' Service Cards, last page.

New Equipment & Literature...



Ceramic Metal Resists 1300 °F Corrosive Vapors

A new ceramic-metal material of construction which combines structural strength and resistance to impact damage with a remarkable resistance to attack in hot, corrosive environments has been samed Nucerite.

The company expects that the material will prove of tremendous value in increasing the rate of chemical reactions which are now held back for lack of a material that will withstand corrosive attack at high temperatures.

Company engineers report that in one of its formulations, the new material has resisted attack by corrosive vapors at 1300°F—a temperature that would destroy most metals in a few minutes under the same conditions. It is expected that even this temperature will be exceeded by several hundred degrees. In aqueous environments its resistance to corrosion is superior to most metals.

A test plate of .020 inch thermally fused soda lime glass an Inconel (photo, left) and Nucerite plate with .020 inch coating in Inconel (photo, right) were angled at 30° and heated to red heat. Upon removal from furnace a ½-pound stainless steel dumbell was placed on each plate near the top edge. A second firing for 15 minutes at 1700°F followed.

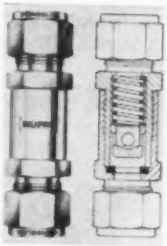
When removed from furnace, the soda lime glass had softened sufficiently to allow the dumbell to skid and remove a major portion of the glass from the metal.

The Nucerite sample did not soften and a major portion of the surface integrity was retained. The Pfaudler Co.

Circle E1 green card, last page

Poppet Check Valve Guards Control Line Flow

A new poppet check valve in the larger size range for ⅜ inch, ½ inch, and ⅝ inch tubing is especially useful in instrument, process and control lines to obtain uni-directional flow. The valve can also be used in fluid service lines to prevent system contamination and equipment damage in the event of accident.



New poppet design of this valve provides large flow areas for minimum pressure drop. Turbulence rings are incorporated to provide dynamic stability and rapid shutoff. The turbulence action "floats" the poppet in the body to eliminate sticking and chattering usually caused by metal-to-metal friction.

One ring of Buna N rubber forms the valve seat to assure bubbletight sealing at low-back pressure and also forms the body seal.

The in-line body design is combined with Swagelok tube fitting connections to provide a compact check valve only 3⅜ inches long and eliminates the need for additional tube fittings. Check valves are available in type 316 stainless steel and brass. Nuclear Products Co.

Circle E2 green card, last page

Steam Trap Combines Trap, Strainer, Blowdown Valve

A new component for steam lines, called the No. 130 Impulse Steam Trap, is an impulse steam trap with strainer and blowdown valve combined in one body. Designed for light condensate loads with steam pressures from 8 to 600 psi, the trap requires only two connections. By eliminating separate strainer and blowdown valve and their necessary fittings, it offers potential installation savings of up to 30 percent, reducing pipe connections by as many as six.

This unique design places the blowdown valve ahead of the strainer screen and trap. Opened and closed by an Allen wrench, the blowdown valve has a threaded outlet for applications where it may be desirable to pipe blowoff away from the immediate area. Yarnall-Waring Co.

Circle E3 green card, last page

B&W WELDING FITTINGS

MADE BY MEN WHO KNOW STEEL

B&W Welding Fittings manufacturing is integrated with the Division's own steel-making and tube-making facilities. Consider the relation between steel-making and the manufacture of welding fittings . . . B&W not only knows the complexities of fittings manufacturing, but also has an intimate knowledge of the making of the steels from which the fittings are formed. Integration plus knowledge naturally makes for a superior product. It enables B&W to provide a completely quality-controlled fitting, matched to end-use service. It also can mean better deliveries of welding fittings made from the specialized steels because B&W can control scheduling from melt to shipment of the finished material.

B&W Welding Fittings and Flanges are available in carbon steel and the B&W CROLOYS in a complete range of types and sizes. Write for B&W Bulletin FB502. The Babcock & Wilcox Company, Tubular Products Division, Welding Fittings Plant, P. O. Box 230, Beaver Falls, Pennsylvania.

B&W

THE BABCOCK & WILCOX COMPANY

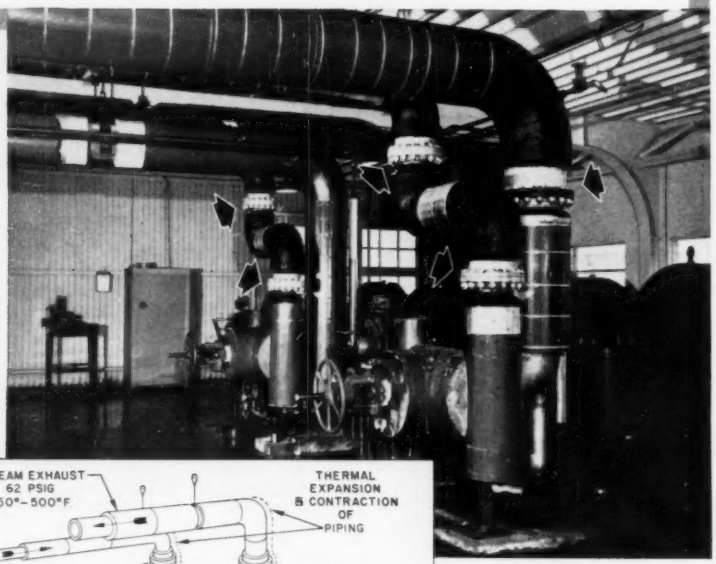
TUBULAR PRODUCTS DIVISION

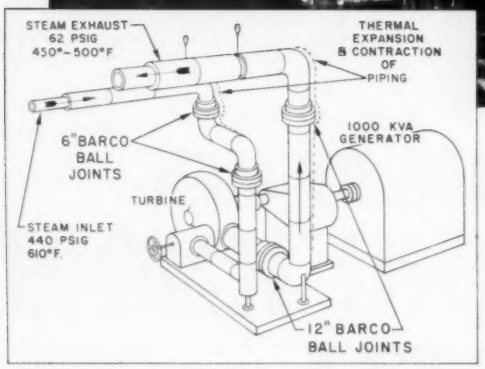
TA-9078-WF1

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

For more data on advertised products, use Readers' Service Cards, last page.

Barco Saves Time, Money on Steam Turbine Piping—





BARCO

BALL JOINTS

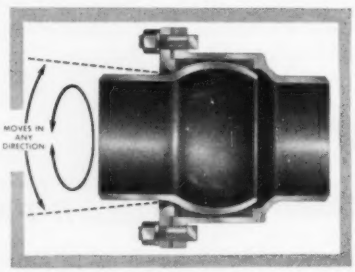
1. Handle Expansion **2. Relieve Torsion** **3. No "End Thrust"**

PROBLEM For the turbine installation shown above, layout of the piping presented involved pipe stress calculations to allow for thermal expansion and to eliminate torsional effects. In addition, a considerable expenditure had to be allocated to cover construction of heavy pipe anchoring and to control expansion "end thrust". *Could engineers find a better way to solve these problems? THEY DID! . . . and they saved about $2,000.00.*

ANSWER Instructions were simple: (A) "Install Barco Ball Joints —two* in each riser near turbine." (B) "Cut loose anchor stops; allow piping to move freely in all directions." (C) "Use spring hanger supports for the long horizontal runs of piping."

*Standard Type N for exhaust; High Temperature Type HT Joints for steam inlet lines.

Barco Ball Joints provide convenient points of flexibility in piping to allow for both expansion and twisting. They develop NO "END THRUST"; expensive anchoring is not required. Easy to engineer. Rugged all-steel construction with no thin wall sections, no critical points of fatigue, no rubber seals. No lubrication required. Sizes and styles to meet your requirements. *Ask for new Bulletin 31B, "Thermal Expansion and Contraction in Piping."*



BARCO MANUFACTURING CO.

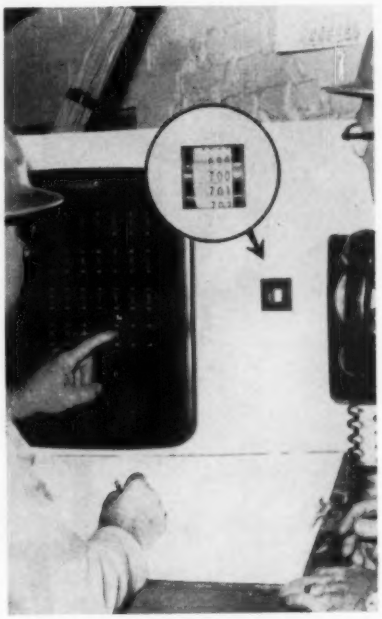
5421 Hough Street, Barrington, Illinois

In Canada: The Holden Co., Ltd., Montreal

New Equipment . . .

Indicator Gives Number Value Of Temperatures

Two operators at DX Sunray's refinery, Duncan, Okla., check crude oil temperatures by using a BH180 AutoTemp indicator. (Inset, added to show how numbers appear, does not indicate an actual temperature reading in the refinery.) The instrument checks oil temperature at 50 points in the refinery's Num-



ber 2 crude unit. The digital reading system eliminates errors which may result with a needle-dial indicator (where the operator must visually interpolate between round numbers on the dial).

To obtain the crude temperature at any one of the check points, the unit operator pushes the appropriate button and the instrument gives the temperature at that point. B & H Instrument Co., Inc.

Circle E4 green card, last page

Transaxle Fluid Additive Withstands High Pressure

A new extreme-pressure additive for automotive and industrial applications, called "Ethyl" Extreme Pressure Additive 1, has been designed specifically for use in automotive transaxle fluids, in gear oils, and in industrial cutting oils. It was developed to meet the increasingly severe "extreme-pressure" conditions being encountered in a number of fields.

In conventional automobiles, separate lubricants are used for the automatic

INTEGRATED PERFORMANCE ...BUILT IN!

On your next contract for construction of a new or expanded process facility, what will you expect in return for the dollars you invest?

For a better-than-average return you can depend on Procon. For Procon gives you this important extra:

From start to finish . . . through estimating, engineering, purchasing, construction, inspection . . . Procon personnel keep an eye on the big objective. Not only must each part of the job be built for perfect performance, but it must also function superbly with every other part. All must work together as a well-knit, fully integrated unit.

Only thus can you be assured of what you really want . . . a completed plant that gives you *maximum production with minimum overhead.*

PROCON INCORPORATED
1111 MT. PROSPECT ROAD,
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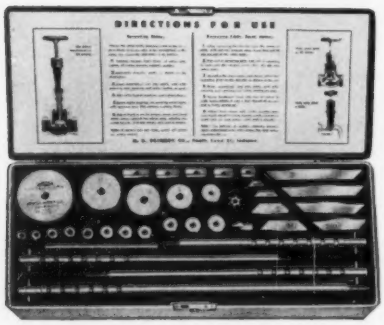
PROCON

PROCON *Incorporated*

WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL AND CHEMICAL INDUSTRIES

For more data on advertised products, use Readers' Service Cards, last page.

RESEATS VALVES and BIBBS QUICKLY ECONOMICALLY



Easily pays for itself on the first two jobs!

Reseats flat and tapered-seat globe or angle valves—all bibbs and faucets—in place, quickly and accurately. The saving, over tearing out and renewing leaky valves and fixtures, is tremendous.

Cutters operating under screw feed, leave worn, scored seats glass-smooth, level, absolutely accurate and tight.

A guide pilot centers each cutter; a tapered cone centers each spindle. Perfect alignment is inevitable. Cutters guaranteed. Write for literature!

2" for ¼" to 2" valves and ¼" to ¾" bibbs
List price $59.85

3" for ¼" to 3" valves and ¼" to ¾" bibbs
List price $79.50

FREE **catalog showing our pipe repair clamps, saddles, and reseating tools**

M. B. SKINNER CO.
SOUTH BEND 21, INDIANA

New Equipment . . .

transmission and rear axle. However, the company pointed out, the addition of EPA 1 to a conventional automatic transmission fluid enables it to meet the extreme pressure requirements of rear-axle hypoid gear oils. Thus, EPA 1 may open the way to a single lubricant for both applications.

Moreover, the company continued, EPA 1 could be particularly valuable as an additive for transaxle fluids. Transaxles, which are a combination transmission and rear axle mechanism, are of increasing interest for possible use on future automobiles.

Discussing the multi-purpose characteristics imparted to lubricating oils by EPA 1, Ethyl said that the compound is compatible with the many other additives used in automatic transmission fluids, and does not promote oxidation.

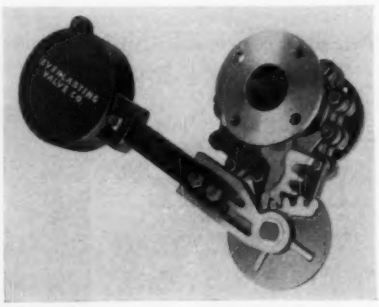
In gear oils, the additive imparts desired load-carrying capacity for protection against gear wear under both high-speed and high-shock loading conditions. In representative tests, a 1 percent concentration of the additive in a base gear oil nearly doubled the load-carrying capacity, as compared with a commercial gear oil. Ethyl Corporation.

Circle E5 green card, last page

Gear Action Operates Emergency Valve

New eccentric gearing designed for the quick-acting pendulum-stop valve cuts down operating weight and reduces space required for emergency protection on fire mains and hazardous liquid lines. By using eccentric gearing, the need for special face-to-face distances between flanges has been eliminated.

Direct gear action opens or closes the disc-type gate valve through torque developed by a free-swinging weight at the end of a lever arm. Gears automatically disengage at the bottom of the swing to prevent damage to the valve mechanism. Gears remesh correctly when the valve is reset.



Both opening or closing (photo) types are used for dip tank discharge, fuel line shutoff, to divert water from service lines to fire mains, for emergency shutoff of hazardous liquid flow, and other emergency protection services. The valves are supplied in standard sizes from ¾ inch up to 8 inches, either flanged or screwed types. Everlasting Valve Co.

Circle E6 green card, last page

Condenser Tube Cleaner Weighs Only 4½ Pounds

A completely new, lightweight condenser tube cleaner designed for use in small, lightly-scaled tubes up to 1-inch diameter, is an economy-priced condenser cleaner which weighs only 4½ pounds. It is designed for one-man operation to quickly clean even the smallest condenser tubes.

The powerful air motor operates on 90 psi at 2,200 rpm, and the balanced

design, coupled with a pistol-grip handle, insures fast, easy operation.

A built-in flashing system, controlled by a brass thumb valve, keeps the drill head cool and removes cuttings. A wide variety of cleaning heads is available for this tool. The Airetool Mfg. Co.

Circle E7 green card, last page

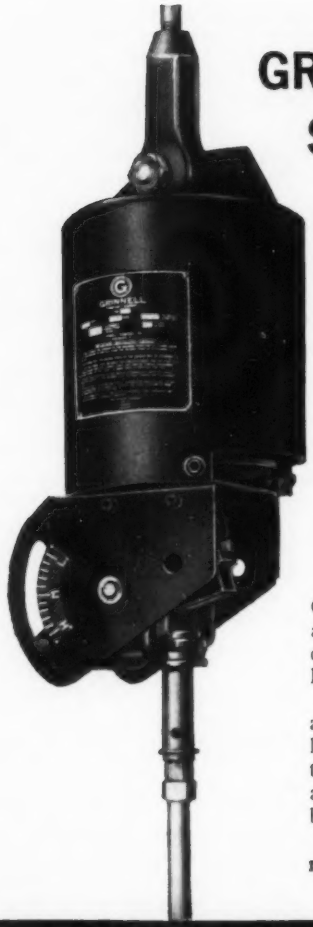
Lube Additive Cuts Bearing Corrosion

Development of a new additive UOP-225, to combat high-temperature deterioration of lubricating oil and reduce bearing corrosion contains no metal or phosphorous. It is stable at temperatures above 500°F and leaves no combustion ash. It is completely soluble in petroleum and synthetic lubricants.

First applications of the new additive probably will be in heavy duty greases, the company predicts. Recommended dosages are one to two percent for dibasic acid or polyol derived lubricants to meet MIL-L-9236A specifications and one-half to one percent for MIL-L-7807 oils, according to company studies.

Advantages of the new additive include corrosion protection for all bearing metals plus titanium, aluminum and magnesium. The inhibitor is compatible with common lube and transmission oil detergents and

GRINNELL CONSTANT SUPPORTS...



2 BASIC DESIGNS...
11 DIFFERENT METHODS OF ATTACHMENT

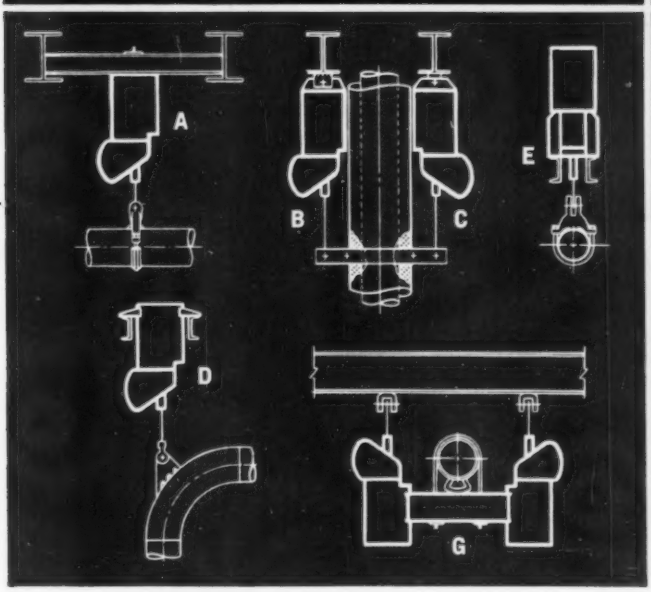
Grinnell Constant Supports are available in a range of sizes to provide capacities for loads from 27 lbs. to 57,500 lbs., with travels up to 16 inches.

Both vertical and horizontal hangers are designed to operate in extremely limited space. In the selection of types, there is a choice of 11 methods of attachment to structures—either above, between, or below supporting steel.

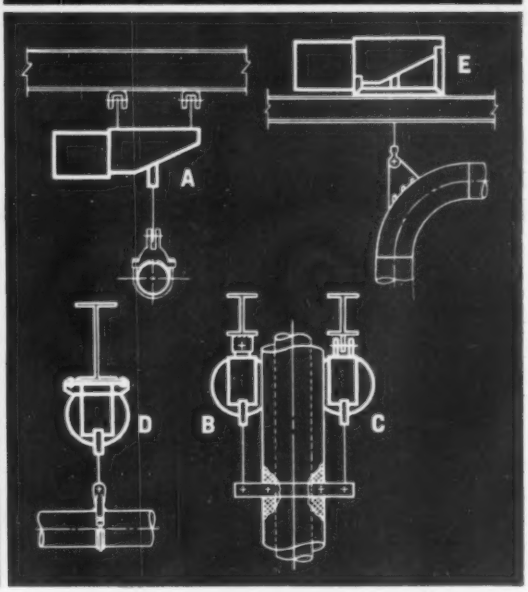
Grinnell Constant Supports provide mathematically perfect load support throughout all positions of travel . . . also a full 70 percentage points of adjustability is built into them. No less than 10% of this adjustability is allowed either side of calibration for plus or minus change in load. Field readjustments are easily made by turning a single load adjustment bolt.

Call on Grinnell's Pipe Suspension Department for help with your pipe suspension problems. Grinnell Company, Providence 1, Rhode Island.

FOR VERTICAL ATTACHMENT



FOR HORIZONTAL ATTACHMENT



GRINNELL

AMERICA'S No. 1 SUPPLIER OF PIPE HANGERS AND SUPPORTS

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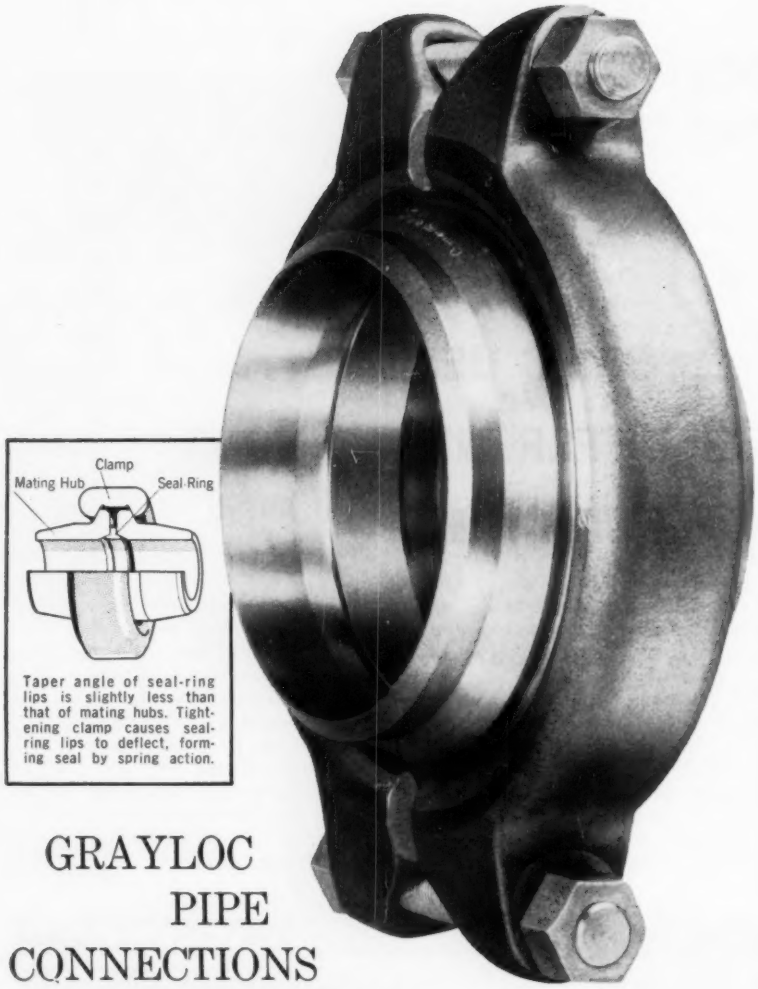


Taper angle of seal-ring lips is slightly less than that of mating hubs. Tightening clamp causes seal-ring lips to deflect, forming seal by spring action.

GRAYLOC PIPE CONNECTIONS HOLD PRESSURE WITHOUT LEAKING

From a full vacuum to extreme internal pressure, GRAYLOC pipe connections will not leak—will not blow out.

It's an all steel assembly with a pressure aided seal that can be quickly and easily disconnected. The seal ring is even re-usable! Yet, for all its sealing power, it's lightweight and small in size.

GRAYLOC pipe connections are manufactured in standard stock sizes from 1″ to 30″, but special sizes can be manufactured on request. They are also available made of corrosion resistant metals.

Learn how GRAYLOC pipe connections can save you time, space and money. Write for the all new GRAYLOC catalog.

GRAYLOC SALES DIVISION

GRAY Tool Company

6006 P. O. BOX 2291 HOUSTON 1, TEXAS Riverside 7-1240

New Equipment . . .

is also suitable for diesel, industrial and electrical transformer oils. It is insoluble in water, a property which, in addition to high-temperature stability, makes it ideal for steam turbine lubricants. Universal Oil Products Co.

Circle E8 green card, last page

Gas Chromatograph Checks Formaldehyde Stream

The use of a GC-2 gas chromatograph to analyze process stream samples during the manufacture of formaldehyde is described in a new application data sheet.

Reichhold Chemicals, Inc., is using the instrument at the firm's Tacoma facility, where the methanol oxidation method is employed in the commercial production of formaldehyde.

Samples for analysis by the chromatograph are drawn from three process stream points: the gas streams at both the converter inlet and outlet, and the tail gas from the absorption tower. Reichhold chemists are working with extremely small concentrations in their analytical work. For example, in some samples, they are measuring formaldehyde which is from 0.10 to 0.25 percent by volume, and carbon monoxide which is from 0.20 to 0.35 percent by volume. In the converter outlet sample, methanol which is from 0.05 to 0.15 percent by volume is measured. Beckman Instruments, Inc.

Circle E9 green card, last page

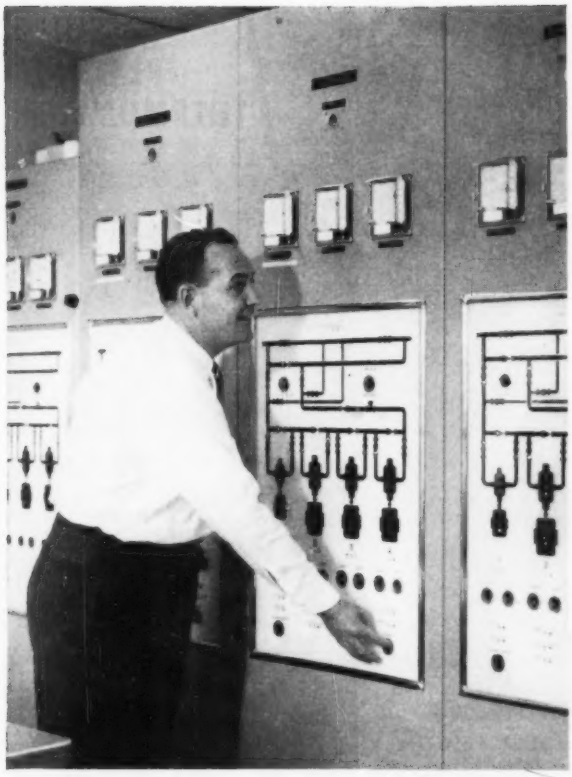
Latest Antiknock Compound Is Mixture of TEL and TML

A new lead antiknock compound which laboratory and road tests indicate provides improved antiknock performance in many of today's gasoline blends combines tetraethyl lead, tetramethyl lead and mixed methyl ethyl lead compounds.

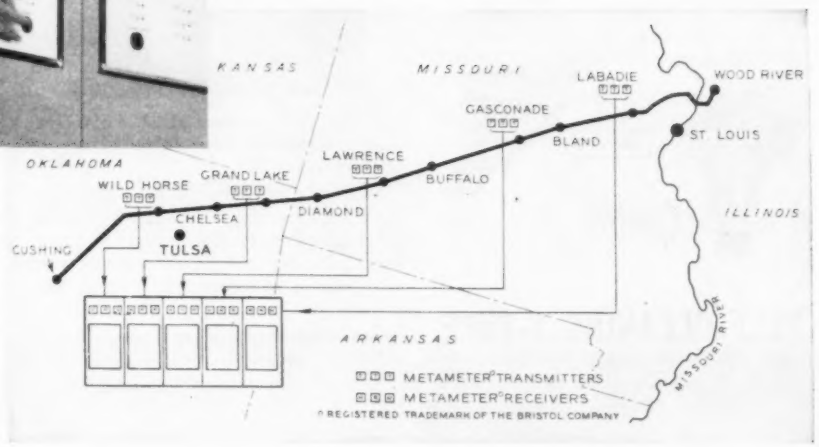
Tests carried out in Du Pont's Petroleum Laboratory show that in many cases desired road octane levels can be achieved more economically with "Tetramix" than with other lead compounds. The company pointed out that, as in the case of tetraethyl lead, the effectiveness of "Tetramix" varies with the composition of the gasoline.

In general, the additive, on a lead-metal weight basis, appears to work better than tetraethyl or tetramethyl lead at all concentrations. It is effective in a wide range of gasolines, the company stated, and offers refiners increased blending flexibility. E. I. du Pont de Nemours & Co., Inc.

Circle E10 green card, last page



Bristol telemetering "mans" half the stations on 400-mile crude oil pipeline



Miniature Bristol Metameter® Telemeter Recorders (top row) on central supervisory control panel at Cushing office of Shell Pipe Line Corporation. Instruments, occupying only 5″x5¼″ on panel, indicate and make permanent record of suction, case, and discharge pressure at each of five unmanned stations along 400-mile pipe line. (See map.)

Bristol Metameter* system permits efficient, instantaneous supervision from central office, frees valuable personnel from routine duties.

Midcontinent Division of Shell Pipe Line Corporation, Houston, Texas, uses a Bristol Metameter System for telemetering on the Ozark Pipe Line System, a 400-mile pipe line from Cushing, Oklahoma, to Wood River, Illinois. This system is jointly owned by Shell Pipe Line Corporation and The Texas Pipe Line Company and is operated by Shell Pipe Line.

The Bristol Metameter telemetering system brings pressure readings from five unmanned pumping stations (out of 10 stations in all) along the pipe line into the central dispatching office in Cushing, Oklahoma. (See map.) Using the telemetered readings, the Cushing office can exercise complete supervisory control over pump operation at the unattended stations. Every other station along the line is manned, including the junction point, Cushing, and the terminus at Wood River. This puts personnel within a reasonable distance to take corrective action if trouble develops.

Whether they're used on oil pipe lines, natural gas pipe lines or distribution systems, electric power systems, water plants, or in steel mills or other industrial plants, Bristol telemeters can practically always improve operating efficiency and cut costs. Their accurate, precise readings are transmitted with the speed of radio (VHF, UHF, microwave), or telephone or carrier current lines for distances that may vary from a few yards to hundreds of miles. Pressure, liquid level, flow (including total corrected flow), temperature, mechanical motion, voltage, current, and power are just a few of the variables that can be transmitted.

Bristol developments in industrial telemetering, soundly based on more than 45 years' experience in this field, are making possible today a speed and an effectiveness in central supervisory control that would have been undreamed of only a few years ago. Let us give you full details. Write: The Bristol Company, 111 Bristol Road, Waterbury 20, Conn.

**T. M. Reg. U. S. Pat. Off.* O.19

BRISTOL... for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

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SARCO

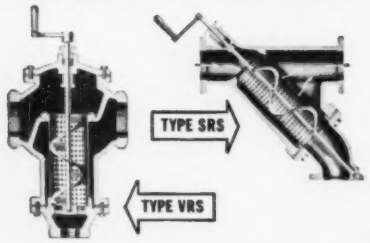
PIPELINE STRAINERS
help prevent shutdowns

HANDLE ALL MEDIA
condensate, steam, water, oil, and other piped fluids

PROTECT ALL EQUIPMENT
temperature and pressure regulators, steam traps, pumps, meters, burners, compressors, hydraulics, lubricators, and nozzles.

AVAILABLE IN ALL TYPES AND SIZES

SCRAPER STRAINERS
hand operated and motorized



SELF-CLEANING Y-TYPE

NEW! TYPE CT CAST STEEL, SPECIFICATION A.S.T.M. — A-216 Gr. WCB

SARCO
Tensile strength 70,000 lbs. per square inch minimum, for saturated steam or liquids to 600 psi, non-shock and 750° F. total temperature.

Also Sarco Y-Type strainers in cast iron, brass, and semi-steel, screwed and flanged, all sizes and pressures.

For information on Sarco strainers, contact your Sarco sales representative, district office, or distributor; or write— -2166

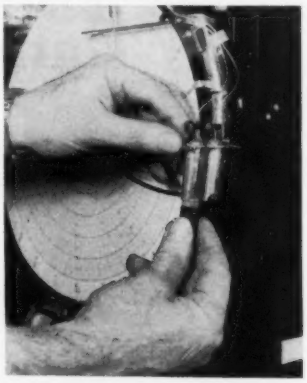
SARCO

SARCO COMPANY, INC.
635 MADISON AVENUE, NEW YORK 22, N. Y.
PLANT: BETHLEHEM, PA.

New Equipment . . .

Non-Clogging Ink Supply In Clear Plastic Cartridges

A new, non-clogging ink supply system, standard equipment on ring-balance meters, features clear plastic ink cartridges that show the ink supply at all times. The cartridges slip into place in a matter of seconds, permitting a closed system that eliminates problems caused



by dust, dirt, and moisture. Cartridges contain a three to four-month ink supply and are disposable.

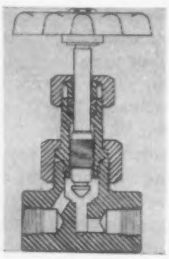
During a six-month indoor and outdoor test program, the system showed no writing failures, no flooding, no clogging. During the test period, the systems were in operation 24 hours a day, seven days a week.

Replacement units are available to apply the system to meters already installed. Hagan Chemicals & Controls, Inc.

Circle E11 green card, last page

Hand Valve Has Floating Cone That Can't Gall

Positive shutoff and freedom from galling are the features of a new "floating cone" ¼-inch hand valve recommended for liquid or gas service. The new valve is supplied in five variations of globe and angle types, accommodating line pressures up to 3,000 psi.



Instead of the conventional one-piece plug and stem, the stem of the new cone valve terminates in a socket which holds the knuckle of a conical-shaped plug. With the plug firmly seated at closure, the stem is free to rotate on the knuckle surface; no amount of further tightening will score the polished cone.

Stem is of type 416 stainless steel;

PRECISION PLATINUM THERMOMETERS

Illustrated Models

MODEL 162A Working standard thermometer. Stability is 0.01 C° over most of range from -182 C° to +260 C° (other models to -265 C° on request). Available on fast delivery.

MODEL 150B Miniature liquid hydrogen probe. The diameter is only 0.160 inches.

MODEL 134D Liquid oxygen probe. Widely used for Missile applications. High stability.

Write for New Catalog No. 115811 for description of 50 different REC probes, including total temperature probes and surface probes.

REC

ROSEMOUNT ENGINEERING COMPANY
4902 West 78th St.
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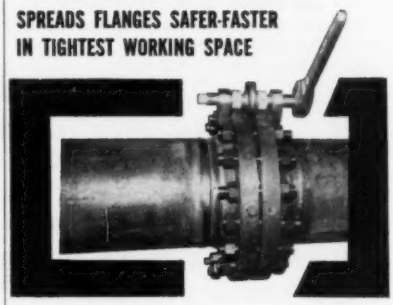
"SAFETY BOY"
SPREADS FLANGES SAFER-FASTER IN TIGHTEST WORKING SPACE



- Eliminates plant safety hazards and costly down time.
- Spreads all Series pipe flanges. Spreads ring joint flanges.
- Lightweight / Priced right

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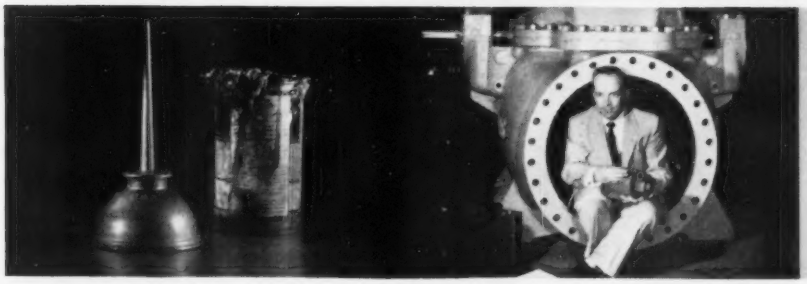
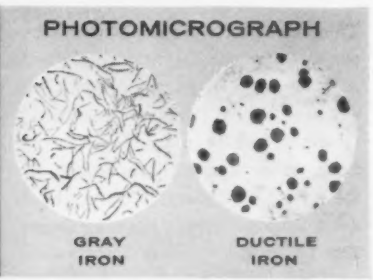
PUMPAGE

Goulds news about pumps for process industries





Lubricate with oil or grease?

If all you're thinking about is lubrication *per se*—oil is better than grease. It's easy to cool, stable, easily replaced. But . . . there are problems. Oil, contaminated by even tiny amounts of moisture, fumes, dust, shortens bearing life. Keeping oil level right for both small and large bearings is difficult. Grease lubrication almost completely solves these problems. It forms a barrier that keeps contaminants from reaching the bearing. It doesn't churn through the bearing, bringing contaminants with it. It *ends* the problem of lubricant level. We feel that grease is a good universal lubricant for pumps and a majority of our new units are available with *either* oil or grease lubrication . . . you have your choice of lubricant to meet the needs of any application.

Centrifugals for cooling towers

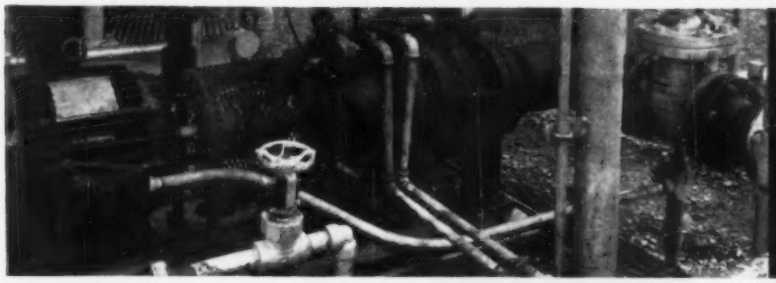
You can pump up to 40,000 gpm from your cooling towers with the mammoth Model 3420 centrifugal pump you see here. Or, if you want the same capacity but more flexibility, try a pair of Model 3405's. In either case, you get a pump that's a cinch to work with should you ever want to go inside it. Horizontally split casing comes apart easily when you remove a few bolts. You don't disturb piping, pump, or driver alignment. You look inside, adjust, maintain in a matter of minutes. Both the Model 3405 and the big job (Model 3420) have proved themselves under the severest services. For construction details, ratings and specifications write us for Bulletins 721.6 and 721.8.

The ductile iron difference

To make ductile iron, magnesium is added to molten cast iron, changing the sharp, thin graphite flakes to spheroids. The spheroids have large areas of iron matrix between them, and since they have no sharp edges, the ductile iron has far greater strength than the original cast iron.

Ductile iron is so tough it can be used in many applications previously requiring cast steel.

It might pay you to look into this. Write us for information on ductile iron pumps or parts.



Intermediate range design . . . new way to handle hot pumpage

You know how it *used* to be—you bought a light duty pump for temperatures up to 200° and a real heavy duty pump to go from 200° to 800°. Consequently, when you were operating in the intermediate range—that area of temperature between 200° and 650°F—you usually had more pump than you needed. Well, that's changed. Here's a process pump that fits into the intermediate range like a glove. It handles all light duty applications and the growing number of intermediate applications as well. Yet it costs very little more than a light duty pump with built-in temperature limitations. For complete application data, drop us a line asking for our bulletin on the Model 3775.

Points on a close-coupled process pump

Here's a brief bulletin—but one loaded with facts—on the Model 3675 close-coupled process pump. It gives you complete specifications on this compact, economical pump which we built expressly for the petroleum industry. It contains full construction details, dimensions, and a handy pressure-temperature chart. For your free copy, just drop us a line. Goulds Pumps, Inc., Dept. PR-100, Seneca Falls, N. Y.

GOULDS PUMPS

For more data on advertised products, use Readers' Service Cards, last page.

Free Chart shows safe methods of Handling Compressed Gases

This new chart, prepared by Matheson's Technical Department, shows safe methods of handling every gas available in cylinders for laboratory or plant use. Step by step illustrations show correct procedures for Receiving Cylinders, Moving, Handling Empty Cylinders, Using Gases. The 14" x 21" chart is designed for wall mounting wherever gases are received, stored or used. Write for your copy.

New Gas Catalog

Our new catalog gives prices and data on 85 compressed gases, gas mixtures and gas regulating equipment. Available on request.

The Matheson Company, Inc.

Compressed Gases and Regulators — East Rutherford, N. J.; Joliet, Ill.; Newark, Calif.

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you don't have to increase pump speed

...to get GREATER PUMP VOLUME

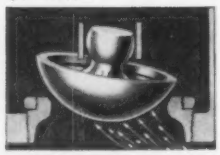
in fact ... the revolutionary Royal Crown Pump Valve increases pump volume with less pump speed! Here's how it operates: Valve is guided by a frictionless ball stem (not a rigid guide) which allows it to oscillate and turn freely with the fluid stream with a minimum of resistance. The result: greater pump volume at a slower pump speed for maximum pump efficiency and economy. Royal Crown Valves have only three separate parts which assures long, trouble-free service. Adaptable to all reciprocating pumps and all liquids.

Royal Crown PUMP VALVES

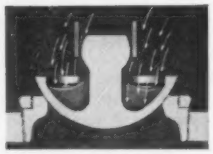
WRITE FOR FREE LITERATURE TODAY

Round valve surface is streamlined. No crossbars or obstructions in seat to restrict the flow of liquid.

Ball-guided valve rotates and swings with each stroke of the pump. Each turn, each swing a lapping action – a perfect seat.



Free vertical action assures instant opening and closing. Ball stem is a frictionless guide.



PELTON Division of
BALDWIN · LIMA · HAMILTON
2447 EAST 54th STREET, LOS ANGELES, CALIFORNIA

New Equipment . . .

packing gland of type 303 stainless; body, bonnet and union nut of heavy duty steel. Teflon ring packing keeps friction to a minimum, requires no lubrication. Bonnet is precision aligned with body for accurate seating of plug; bonnet seat checks rise of stem and provides seal to permit repacking at full-line pressure. The Foxboro Co.

Circle E12 green card, last page

Heat Exchanger Cools Mechanical Seals

A new type of heat exchanger has been developed to cool mechanical seals.

It has a capacity of 10,000 Btu per hour, but two or more units can be used either in series or in parallel, when the rate of flow and the required temperature drop exceed the capacity of a single unit.

With the exception of the connections for the coolant, which are mild steel, cadmium plated, the whole of the metal component parts of the "heat dissipater" are manufactured from stainless steel, in order that it may be proof against the attack of corrosive liquids or gases which are passed through it.

It is designed for pressures up to 2,000 psi for the product and 150 psi for the coolant. Crane Packing, Ltd.

Circle E13 green card, last page

Pipe Connection Catalog Includes Special Table

A 44-page catalog of pipe connections and accessories designed on the new Grayloc seal principle contains all new types and ratings of Grayloc clamps, collar-type unions, flanges, vessel nozzles, closures, and bleeder valves. Products with related applications are also cataloged, including bi-metallic pipe, fittings.

A special feature of the new literature

REFRACTORY HAYDITE

Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.
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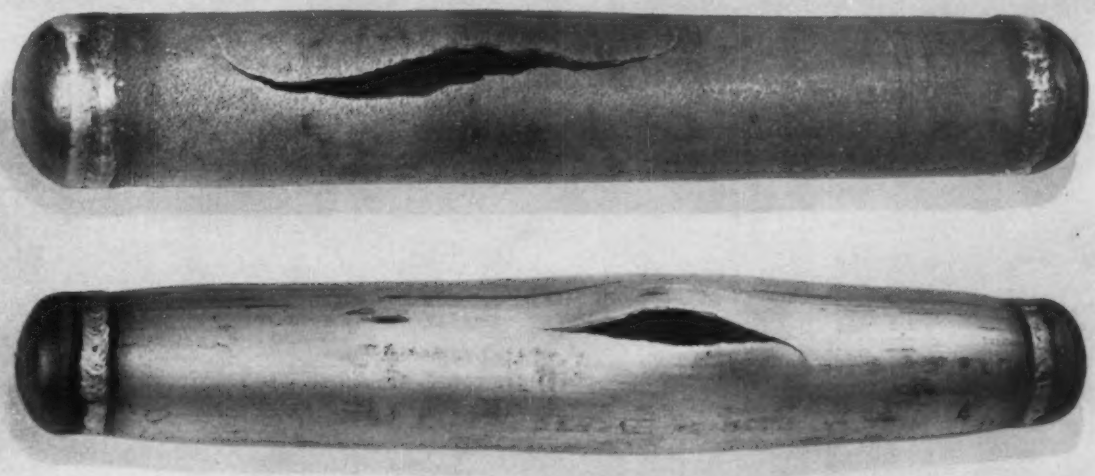
2440 Pennway — Phone GRand 1-2570

Centrifugally cast Thermalloy tube burst at 77,500 psi



Wrought tube burst at 70,100 psi

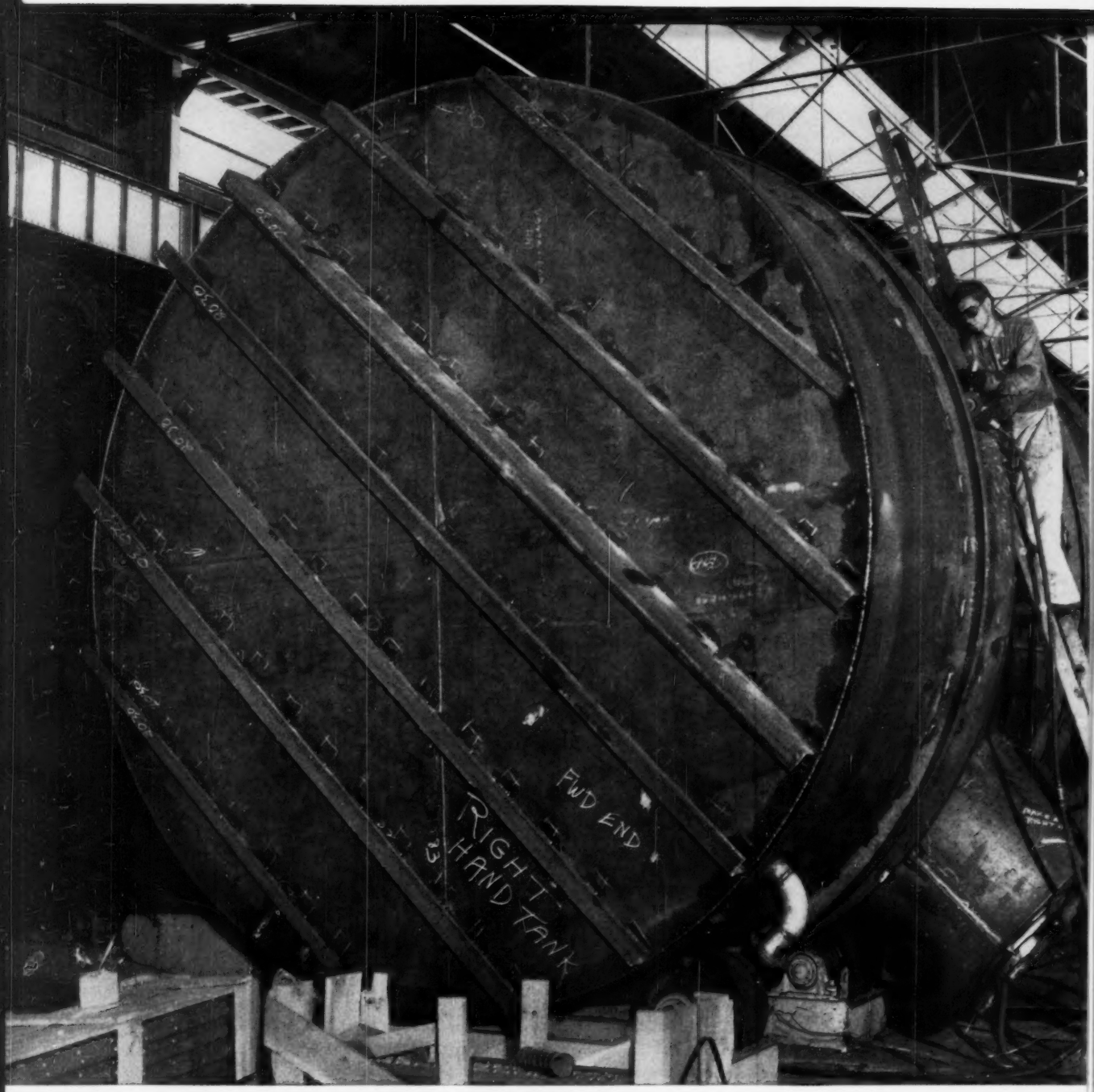
Burst tests prove 7,400 psi superiority of centrifugally cast Thermalloy® tubes

Hydrostatic pressure tests by Electro-Alloys established the rupture of a centrifugally cast Thermalloy tube section at 77,500 psi. Under the same conditions, wrought tubes of comparable section and analysis burst at 70,100 psi. These tests were conducted at room temperatures. Tensile tests show this strength margin increases substantially at the higher operating temperatures (1500° — 1800° F). The Thermalloy tube was tested *as cast*—without machining the inside or outside diameter. For further data, call your representative, or write Electro-Alloys Division, 20210 Taylor Street, Elyria, Ohio.

AMERICAN Brake Shoe COMPANY

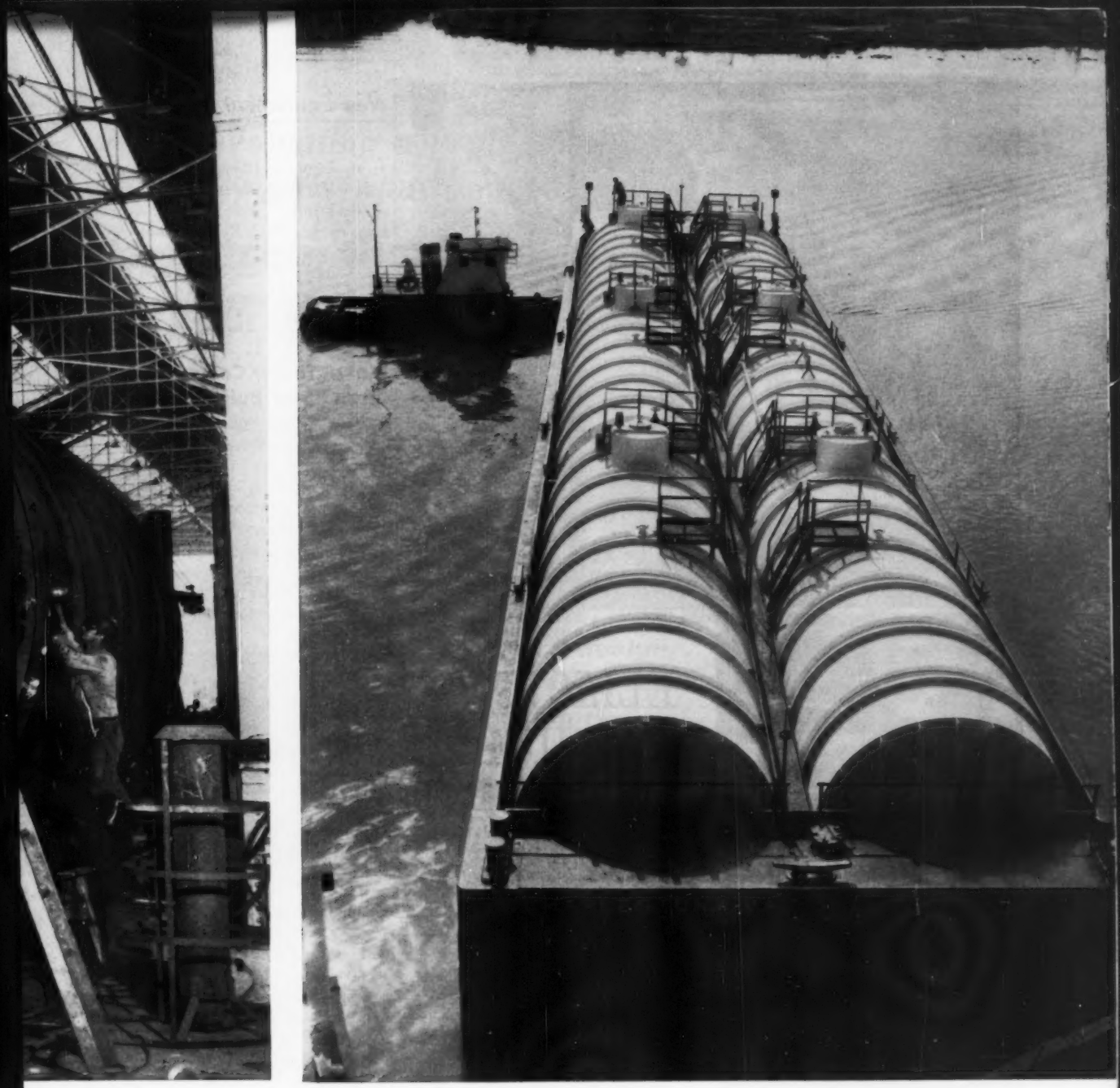
ELECTRO-ALLOYS DIVISION • Elyria, Ohio

For more data on advertised products, use Readers' Service Cards, last page.



Tanks as big as a barge can carry

These new tanks have unobstructed interiors to carry maximum cargo with least danger of contamination—the essential requirements of an order for two independent tank barges from Union Carbide Chemicals Company. One barge is designed to carry Grade A and lower liquids having a Reid Vapor Pressure not exceeding 25 psi. The other barge will carry similar cargoes having a Reid Vapor Pressure not exceeding 40 psi. ☐ American Bridge designed and constructed the tanks and barges at its modern Plate Shop in Orange, Texas. The results: two Jumbo Hopper Barges 195′ x 35′ containing six tanks 52′ long x 14′-6″ O.D. and weighing 22 tons with a total



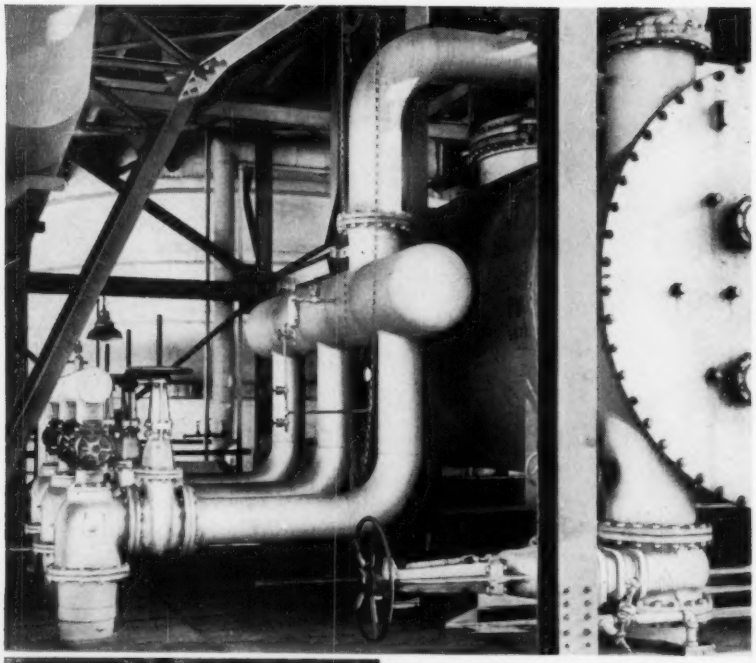
capacity of 383,000 gals. per barge. The reinforcing members for the tanks were placed on the tank exteriors leaving unobstructed nickel-plated interiors. ☐ Whatever your plate needs, we have the staff and facilities to take care of them, and our strategic location permits shipment by train, truck or barge. Write for our booklet completely describing plate fabricating and construction services.

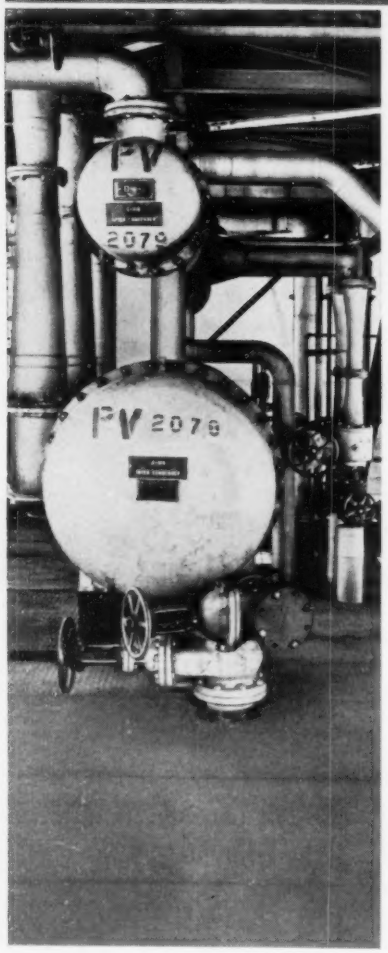
USS is a registered trademark

General Offices: 525 William Penn Place, Pittsburgh, Pa.
Contracting Offices in: Ambridge • Atlanta • Baltimore • Birmingham • Boston • Chicago • Cincinnati Cleveland • Dallas • Denver • Detroit • Elmira • Gary • Harrisburg, Pa. • Houston • Los Angeles Memphis • Minneapolis • New York • Orange, Texas • Philadelphia • Pittsburgh • Portland, Ore. Roanoke • St. Louis • San Francisco • Trenton • United States Steel Export Company, New York

American Bridge Division of United States Steel

USS





ELLIOTT VACUUM EQUIPMENT

maintains pressure of 75 to 100 mm Hg absolute in crude oil distillation unit

TWO-STAGE EJECTORS, with an Elliott 20,000-sq. ft. precondenser, a 3000-sq. ft. intercondenser, and a 900-sq. ft. aftercondenser were designed by Elliott Company to serve a new distillation unit. Suction chambers and diffuser inlets of the three 12-inch first-stage ejectors are shown at lower left in photo above.

BELOW THE FLOOR, left, are the vertical diffusers of the three 12-in. first-stage Elliott ejectors which exhaust into the 3000-sq. ft. Elliott intercondenser. Two 6-in. second stage ejectors, seen at the right, discharge into the aftercondenser.

ELLIOTT Company
Jeannette, Pa.

GO-2

New Equipment . . .

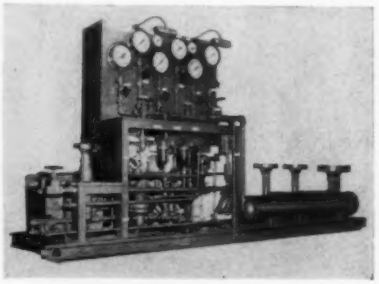
is an exclusive 10-page table of allowable working pressures for pipe and connections from 1 inch to 30 inches inclusive to 1,500°F. Relative costs of 39 piping materials are also tabulated in this working manual. Gray Tool Co.

Circle E14 green card, last page

Valve Tester Costs Less Than Plant-Built Stand

Now available at ⅓ cost of built-in-plant test stands, this universal unit manufactured to ASME requirements will test all valves including globe, gate, plug cocks, safety and relief plus other hydraulic-pneumatic equipment.

This new test stand completely eliminates expensive, time-consuming outside valve maintenance and related shipping costs. Valve inventory can be reduced to



a minimum by using the test stand to reset valves to use them in the widest possible variety of applications and pressure variations.

Easy to operate, the universal test stand requires no special skill or training. All controls are within reach on one panel with simple instructions printed on a metal plate. It is compact (10½ feet x 3 feet) yet its wide range permits testing of pressure settings up to 2,000 psi for air and 6,000 psi for water. Farris Engineering Corp.

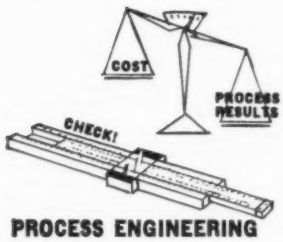
Circle E15 green card, last page

Ultra-Fast Computer Is Classed As Low Priced

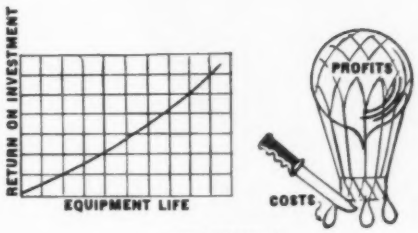
A new ultra-fast general purpose, digital computer combines a large, expandable memory and a versatile command structure with computing speed in the microsecond range. Until now, these combined features were available only in the largest computers priced over $200,-

When evaluating a product, one generally gets what one pays for—

At Glitsch, the interests of each individual on your staff receive consideration—

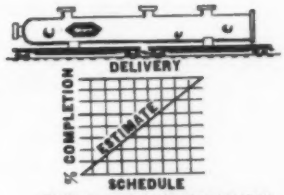


PROCESS ENGINEERING



EXECUTIVE

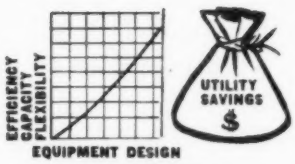
PURCHASING



FIELD CONSTRUCTION

Glitsch products, with their plus-quality of design, offer many added values for your account—

ENGINEERING & ESTIMATING



OPERATING

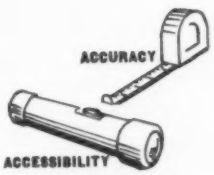
MAINTENANCE

TECHNICAL — **Fractionating Tray Engineering:** Process, Mechanical, Structural, and Metallurgical Designing. **Pressure Vessel Engineering:** Pressure, Temperature, Wind, Earthquake, and Dynamic Designing. **Special Product Engineering:** Research and Development and Model Mock-Up. **Special Tooling and Machine Design** for Specific Purposes and Problems.

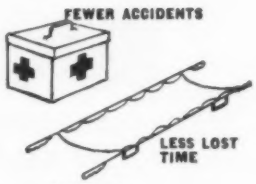
MANUFACTURING — **Plate and Sheet Equipment:** Shears, Draw and Punch Presses, Perforating Machines, Resistance and Inert Gas Welders, Press Brakes, Flangers, and Rolls. **Heavy Plate Equipment:** Large Furnaces, 6″ Capacity Bending Rolls, Angle Rolls, Hydro Presses, Flanged and Dished Head Formers, Submerged Arc Welders, Magnaflux, and X- and Gamma-Ray. **Tool and Die Shop Equipment:** Grinders, Milling Machines, Shapers, and Lathes. **Machine Shop Equipment:** 15′ Boring Mill, 84″ x 20′ Planer, 84″x22′ Lathe, 8′ Radial Drill, 40′ Plate Edge Planer, 8-Spindle Heavy-Duty Drill, and Other Machine Tools.

PRODUCTS — Glitsch Lightweight "Truss-Type" Ballast Trays, Sieve, Bubble Cap, Dualflow, Disc, Donut, Accumulator, and Mist Eliminator Trays . . . Pressure Vessels, Contactors, Reactors, Filters, Heat Exchangers, and Other Specialty Products . . . Bubble Cap and Riser Assemblies, Flanged and Dished Heads, Machine Time, Stampings, Knitted Wire and Woven Wire Screen.

MATERIALS — Specialists in Forming, Weaving, Fabricating, Stamping, Perforating, Machining, and Welding of Copper, Monel, Aluminum, Stainless Steels, Carbon Steel, Inconel, Titanium, Nickel, and the Noble Metals.



INSPECTION



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GOODLOE PACKING

LOW COST, HIGH CAPACITY, LOW H.E.T.P.
MINIMUM PRESSURE DROP, PROVEN COMMERCIALLY

327 Installations to date—19mm. to 67.75 in. dia.

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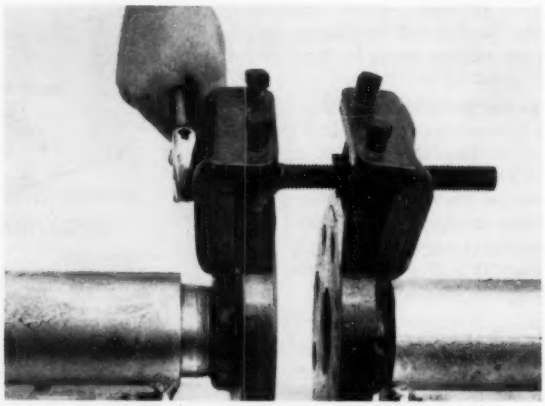
A Column Packing For Every Application



SPREAD ANY FLANGE SAFELY IN SECONDS WITH THE NEW NATIONAL FLANGE SPREADER!

From National Tools comes the safest, most efficient flange spreader ever marketed! No wedge! No sparks! No danger! See this brand new flange spreader at the Permian Basin Oil Show in Odessa, Texas October 20-23. And for more information, write:

NATIONAL TOOLS

Serving the World's Industry
Post Office Box 15525
Tulsa, Oklahoma
Phone WE 6-8802

New Equipment . . .

000. The PB250 is priced at $30,000.

The unit excels as (1) an engineer's desk-side computer, and (2) an on-line computer for process monitoring, process control, data-logging, and alarm generation. Packard Bell Computer Corp.

Circle E16 green card, last page

Brochure On Corrosion Control In Refineries

Corrosion control in petroleum refinery processing systems is covered in a six-page brochure. Featured is a discussion of three questions: "Is Corrosion Control Worthwhile?" "How Can You Prevent Corrosion?" and "What Makes Corrosion Inhibitors Work?"

An unusual center spread is devoted to a simplified refinery flow diagram showing how filming corrosion inhibitors can be applied to a variety of streams. Short case histories reporting typical problems solved by filming inhibitors are included. Nalco Chemical Co.

Circle E17 green card, last page

Condensed Catalog Has Steam Trap Capacity Data

The 1960 edition of the company' condensed catalog contains 12 pages of technical details, dimensions, and capacity data on the most widely-used devices in the complete line of steam traps, temperature regulators, and heating specialties. Sarco Co., Inc.

Circle E18 green card, last page

Platinum Catalyst Gives Higher Reformer Yields

Three new types of reforming catalysts which can be used in any type of platinum reforming unit, under high as well as low-pressure operating conditions, are said to give improved yields of high-octane gasoline.

The 1/16-inch extruded CK-303, CK-306 and CK-307 catalysts are improved over the company's type CK-103 and CK-106 catalysts. The new types show excellent activity and maintenance stability and are fully regenerable. Nederlandsch Verkoopkantoor Voor Chemische Producten N. V.

Circle E19 green card, last page

Bubble Tray Is Subject Of Engineering Brochure

A new brochure is now available describing float valve bubble trays, which

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Babbitt *Adjustable* SPROCKET RIM
with Chain Guide
CHANGES THAT DANGER ZONE TO A
SAFETY ZONE

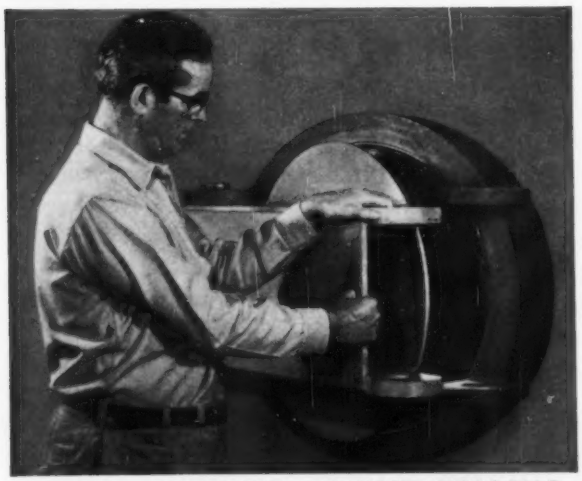
. . . saves you money ON EVERY VALVE

Every minute saved is money in your pocket. Cut out the waste of time, labor, floor space due to hard-to-reach valves. At the same time, convert Danger Zones to Safety Zones. Equip every overhead valve in your plant with Babbitt Adjustable Sprocket Rims with Chain Guides for day to day economy.

- They simplify pipe layout.
- They fit any size valve wheel.
- They are easy to install and operate.
- They operate any valve from the floor.
- They save time and money.
- The first cost is the only cost (no maintenance).
- They are packed completely assembled (one to a carton), with easy-to-follow instructions.
- A hot-galvanized rust proof chain is available for all sizes.

Babbitt Adjustable Sprocket Rims with Chain Guide are carried in stock by most mill supply houses. Just phone your mill supply salesman, or contact us direct.

Babbitt STEAM SPECIALTY CO.
6 BABBITT SQUARE, NEW BEDFORD, MASS., U.S.A.



QUICK OPENING • TIGHT SEALING

To open a LENAPE QUICK OPENING MANWAY you just remove one pin and swing it open—no bolts to remove . . . no tools required.

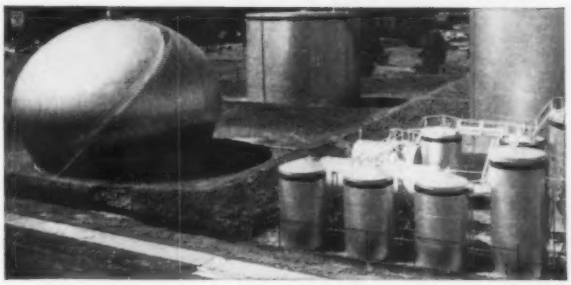
Tight sealing gasket assures leakproof closure. Wide range of sizes and pressure ratings available.

See pages 62-65 of the Lenape General Catalog for full details and specifications. Write for your copy.

LENAPE
Red Man Products
LENAPE HYDRAULIC PRESSING & FORGING CO.
DEPT. 106 WEST CHESTER, PENNSYLVANIA

STOP WEEDS YEAR 'ROUND

with UROX® Weed Killer



Just one application controls weeds and brush for 8 to 18 months!

Don't take chances! Wherever weeds and brush are a fire hazard—on tank farms, along pipelines, around refineries and pumping stations—wipe them out faster, easier and at lower cost with amazingly effective UROX Weed Killer.

Longer lasting! Economical! One application gives you 8 to 18 months control. And effects are cumulative. Light "booster" doses extend control from year to year.

Available in 2 easy-to-use forms! *Liquid* UROX Weed Killer is ideal for spraying large overgrown areas. Won't clog spray nozzles or strainers. Does not precipitate out in the tank. Stays in solution perfectly. *Granular* UROX is the convenient, inexpensive way to treat small weed-infested areas. Can be applied quickly and easily with any mechanical or hand-operated spreader.

Send coupon today for free folder on the use of non-flammable UROX to prevent brush and weed fires!

Allied Chemical
GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

Weed Killer Dept. PR 100
GENERAL CHEMICAL DIVISION
Allied Chemical Corporation
40 Rector Street, New York 6, N.Y.
Please send free copy of the new UROX folder, "Fire! Fire!"
Name_____
Title_____
Company_____
Address_____
City_____ Zone____ State_____

Anderson Quik-Flex Thermostatic Steam Trap— Guaranteed Freeze-proof for Two Years!

Guaranteed when properly installed and operated, this freeze-proof Anderson Quik-Flex Thermostatic Steam Trap is ideal for tracer lines, meter boxes, drips and other outdoor steam processing equipment used in chemical, refinery, solvent and other industrial plants.

Correct installation requires free condensate drainage on the discharge side. A cooling leg of at least three feet is a necessity to cool condensate, since thermostatic traps operate on temperature differential. The strainer should be installed in a down position to avoid freezes which could break the strainer body.

A TRAP FOR EVERY PURPOSE

THE V. D. ANDERSON COMPANY
division of International Basic Economy Corporation
1953 West 96th Street • Cleveland 2, Ohio
Please send without obligation your Bulletin No. 257

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ANDERSON QUIK-FLEX

New Equipment . . .

are now in extensive use. This brochure deals with the fundamentals of design and operation, mechanical features, operating results, general design arrangement and, finally, a listing of some 86 companies who have had experience with the equipment. Nutter Engineering Co.

Circle E20 green card, last page

Booklet Answers Question "When Is A Low Bid Low?"

A new 12-page booklet discusses the historic conflict between low-dollar first costs and long-range economy. The booklet emphasizes that the calculation and evaluation of capital process equipment can no longer be a matter of "guestimates" or conjecture but must be based on the practical facts of economic life. The booklet discusses the question, "When is a low bid really low?" and points out the multitude of factors that must be considered to arrive at the proper answer. Western Supply Co.

Circle E21 green card, last page

Bus Duct Application Information In Catalog

Application data for plug-in, low-impedance, high-frequency and electric-utility bus ducts are contained in a new 12-page booklet.

The general information, descriptions and drawings in the publication illustrate a variety of applications for these four types of bus ducts. Westinghouse Electric Corp.

Circle E22 green card, last page

Technical Data Brochure On Vertical Tube Boilers

A new descriptive brochure includes technical data and complete specifications on a line of vertical tube boilers. Included in the data are tables including ranges and working pressures, sizes for valves and fittings of various units, together with weights, dimensions, data on heating surfaces, capacities and fuel consumption. Redheugh Iron & Steel Co., Ltd.

Circle E23 green card, last page

56-Page Book Has Complete Acetonitrile Information

A new 56-page guide book, a complete source for acetonitrile information, gives reactions, physical properties, information on specific uses, and a bibliography containing 134 references.

Until recently, the economics of acetonitrile discouraged the sort of research and development investigations which this chemical deserves. Sohio Chemical Co.

Circle E24 green card, last page

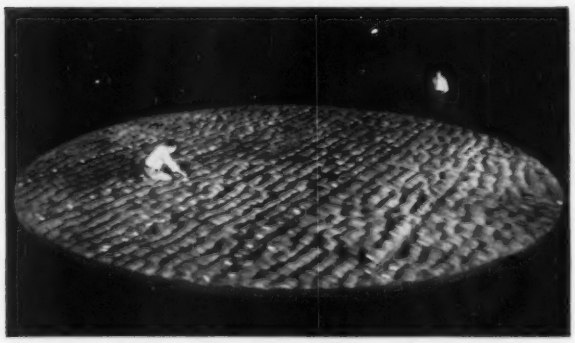
METEX MIST ELIMINATORS

... the First name in knitted wire entrainment separators!

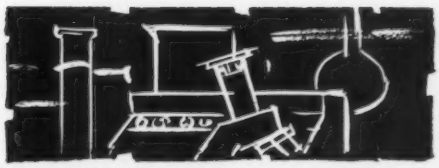
FIRST with strip-type construction
FIRST with wound-type construction
FIRST with Hi-Thruput® mesh
FIRST with fiberglas coalescers
FIRST with all-metal coalescers
FIRST with polyethylene
NOW FIRST with Teflon®

Since 1943, when it first introduced knitted wire entrainment separators—Metal Textile has been consistently first in introducing new developments to the field. In response to requests from chemical and processing engineers throughout industry—Metex engineers have utilized new materials...developed special meshes ...initiated revolutionary techniques to provide low-cost, high-efficiency answers to the most complex entrainment problems. Your specific needs can be similarly solved. Our engineers, backed by the most extensive research and production facilities in the field, will be glad to recommend the type of Metex Mist Eliminator and method of installation best suited to your particular operating conditions. For latest design guides, write or call for Bulletin ME-9: Metal Textile Corporation, Roselle, New Jersey.

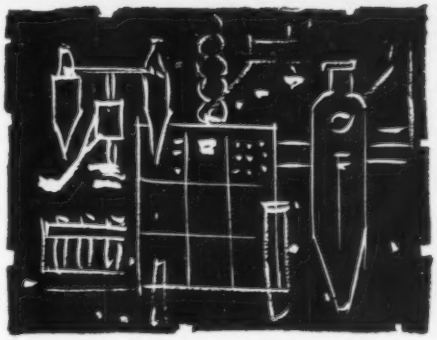
38' dia. Metex Hi-Thruput Mist Eliminator for world's largest vacuum pipe still.



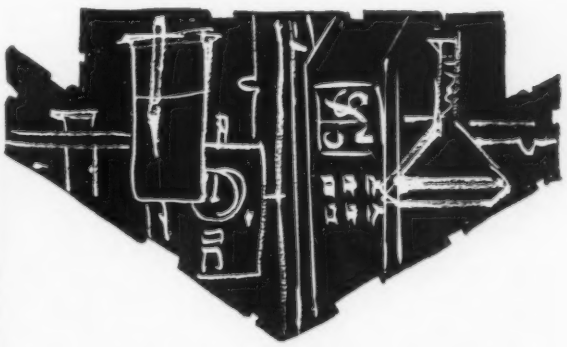
METAL TEXTILE CORPORATION
...world's largest and oldest producer of knitted wire products
A DIVISION OF GENERAL CABLE CORPORATION



EVERYTHING FOR THE PETROLEUM LABORATORY



Curtin's conveniently located warehouses throughout the South and Southwest have everything for the petroleum laboratory in stock and ready for immediate delivery. Repair service and technical assistance are always available to Curtin customers. Save time and money by ordering all your laboratory requirements from Curtin, where complete stocks and facilities assure you of the best service.



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HOUSTON • DALLAS • TULSA • NEW ORLEANS
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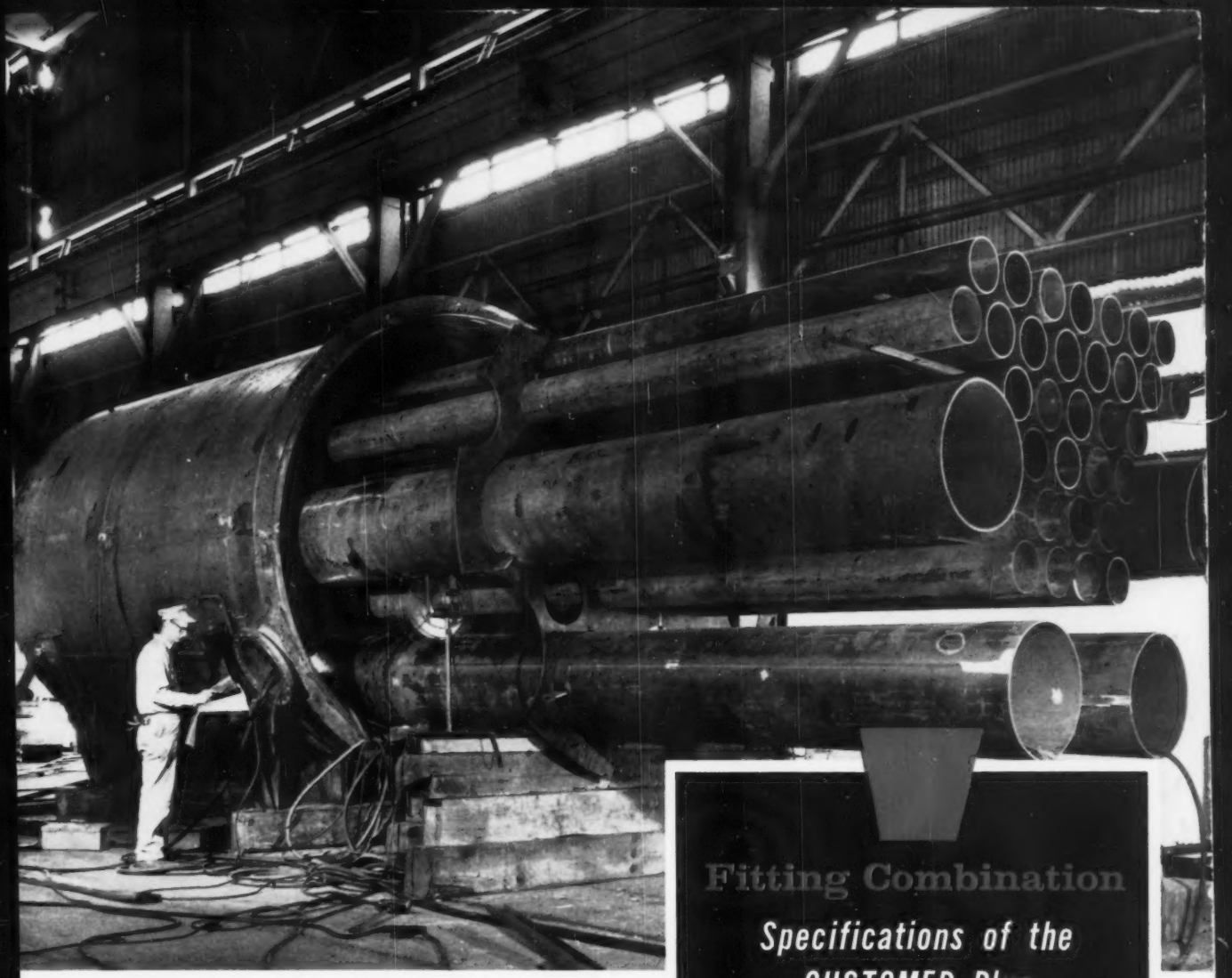

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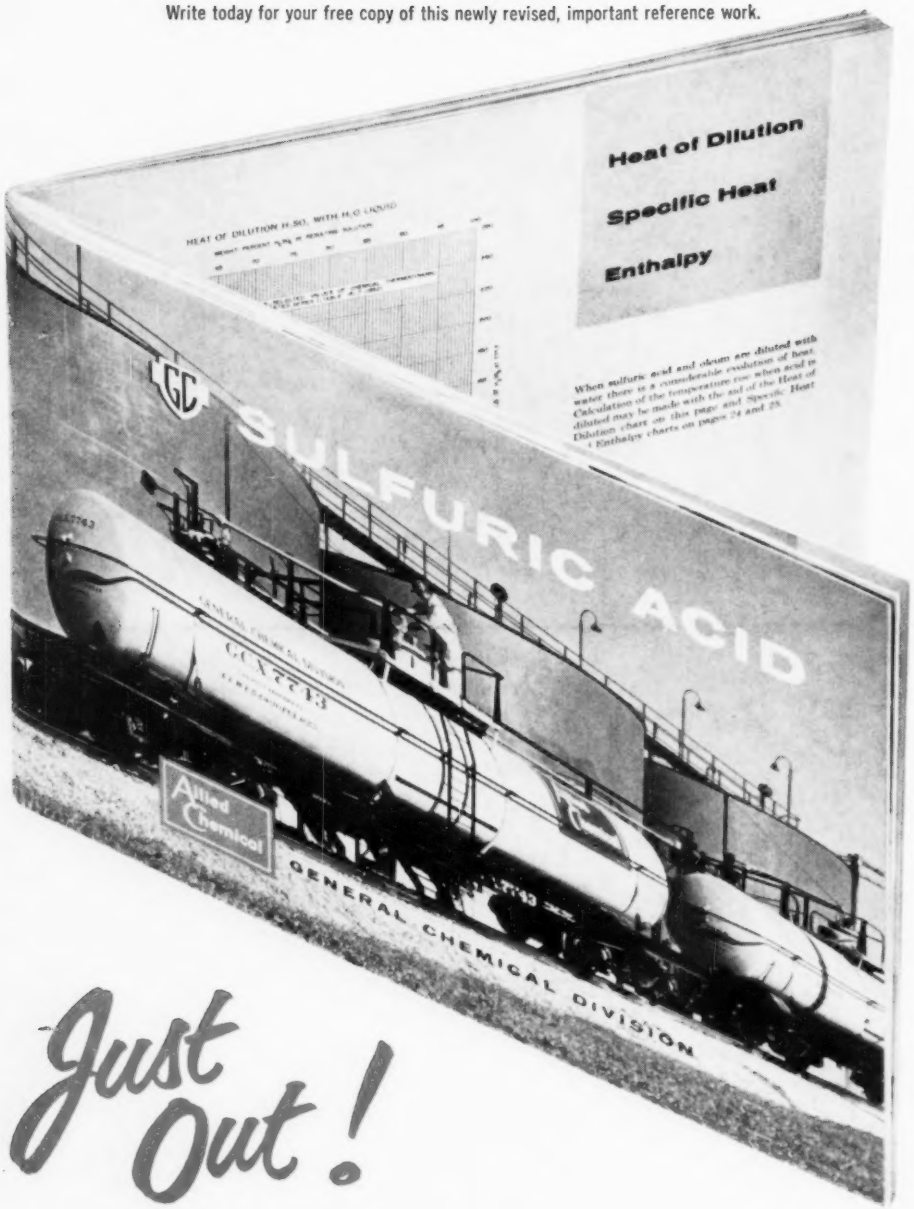
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